



US005761618A

United States Patent [19]

Lynch et al.

[11] Patent Number: **5,761,618**[45] Date of Patent: **Jun. 2, 1998**

[54] **UPDATING TECHNIQUE FOR
DOWNLOADING NEW SYSTEM
IDENTIFICATION (SID) LIST INTO A
HANDSET**

[75] Inventors: **Richard Lynch, Yardley, Pa.; Robert
T. Braun, Pittstown; Michael
Haberman, Morris Plains, both of N.J.**

[73] Assignee: **Bell Atlantic Mobile Systems, Inc.,
Bedminster, N.J.**

5,144,649 9/1992 Zicker et al. .
5,159,625 10/1992 Zicker .
5,247,564 9/1993 Zicker .
5,261,117 11/1993 Olson .
5,285,494 2/1994 Sprecher et al. .
5,297,191 3/1994 Gerszberg .
5,313,653 5/1994 Sasuta .
5,442,806 8/1995 Barber et al. 455/33.1
5,454,027 9/1995 Kennedy et al. 379/60
5,504,803 4/1996 Yamada et al. 379/59
5,613,204 3/1997 Haberman et al. 455/432

[21] Appl. No.: **362,306**

[22] Filed: **Dec. 22, 1994**

[51] Int. Cl.⁶ **H04Q 7/20; H04Q 7/38**

[52] U.S. Cl. **455/419; 455/432; 455/435;
455/436; 455/517; 455/552**

[58] Field of Search **379/58, 59, 60,
379/61, 62; 455/33.1, 33.2, 54.1, 54.2,
406, 418, 419, 422, 424, 425, 432, 435,
436, 552, 560, 517, 515**

[56] **References Cited****U.S. PATENT DOCUMENTS**

4,166,927 9/1979 Hamsoki .
4,456,793 6/1984 Baker et al. .
4,475,010 10/1984 Huensch et al. .
4,513,415 4/1985 Martinez .
4,718,081 1/1988 Brenig .
4,754,453 6/1988 Eizenhofer .
4,850,033 7/1989 Eizenhofer et al. .
5,046,082 9/1991 Zicker et al. .

Primary Examiner—Dwayne Bost

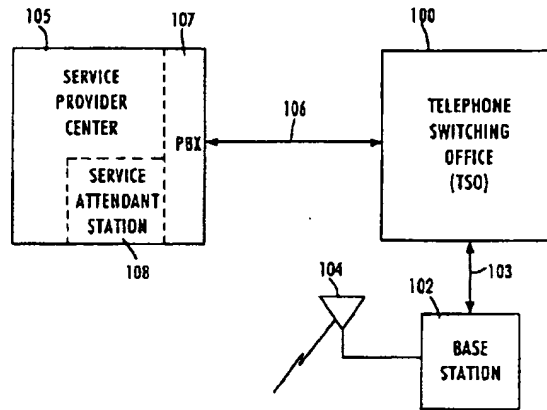
Assistant Examiner—Nay Maung

Attorney, Agent, or Firm—Lowe, Price, LeBlanc & Becker

[57] **ABSTRACT**

A cellular telephone system is upgraded by modifying subscriber units for selective service provider acquisition during roaming. Priority of acquisition is given to those service providers associated with the home service provider. These preferred service providers are identified by System Identification (SIDs) numbers. A roaming subscriber unit will tune to control frequencies to identify all of the system providers operating in a physical area to which the subscriber has roamed. The SIDs of those system providers available are compared to a preferred SID list contained within the subscriber unit. Selection is made based upon a priority of those system providers having arrangements with the home system provider. The SID lists in the subscriber units are modified based upon a version number for each update on the SID list.

34 Claims, 7 Drawing Sheets



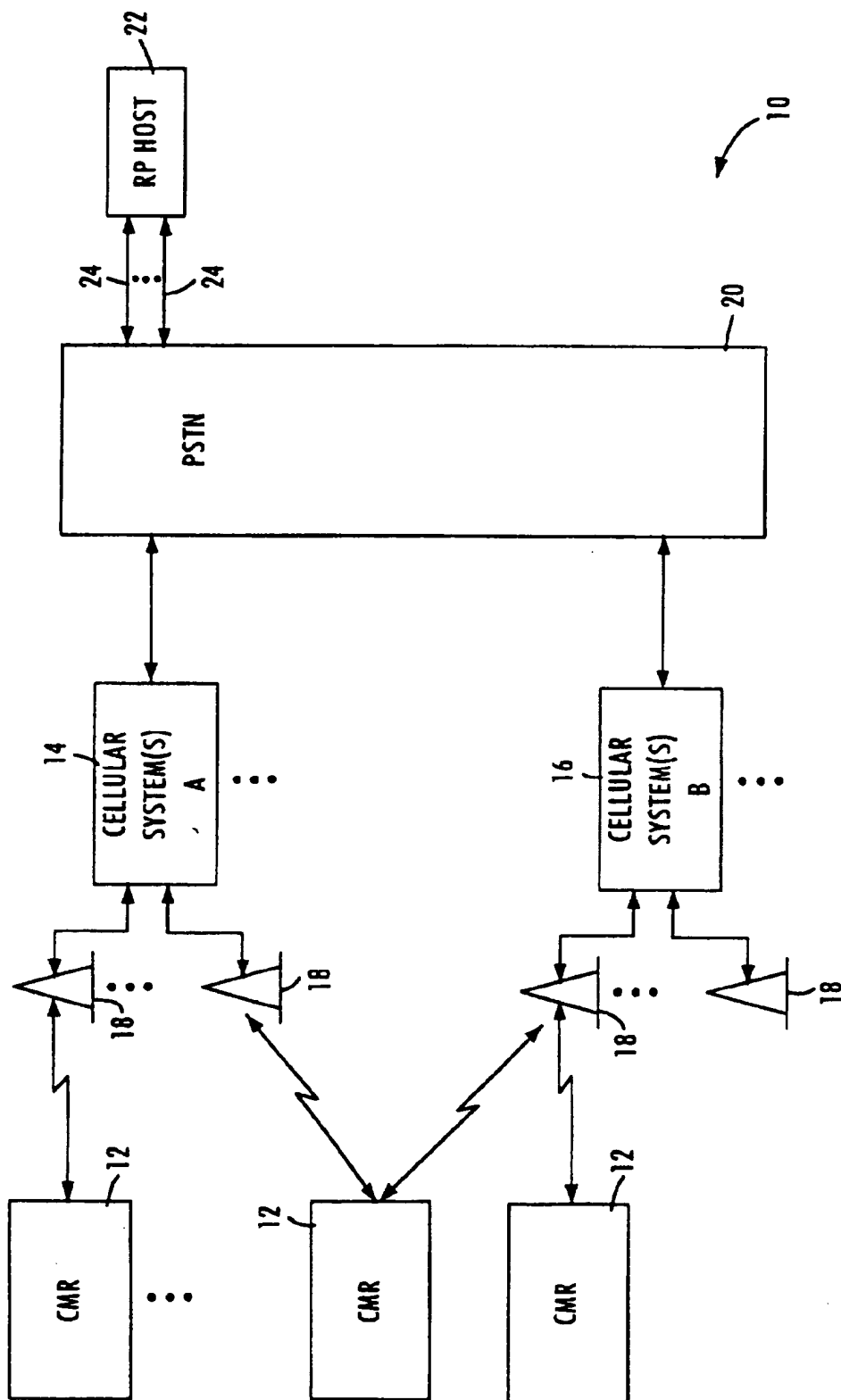


FIG. 1

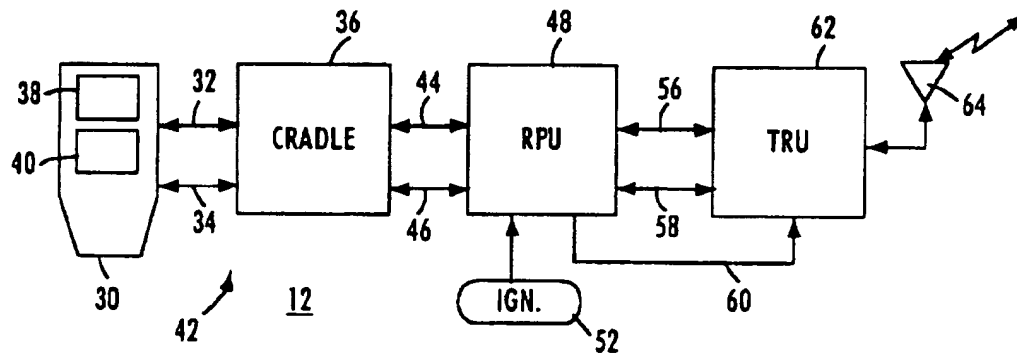


FIG. 2

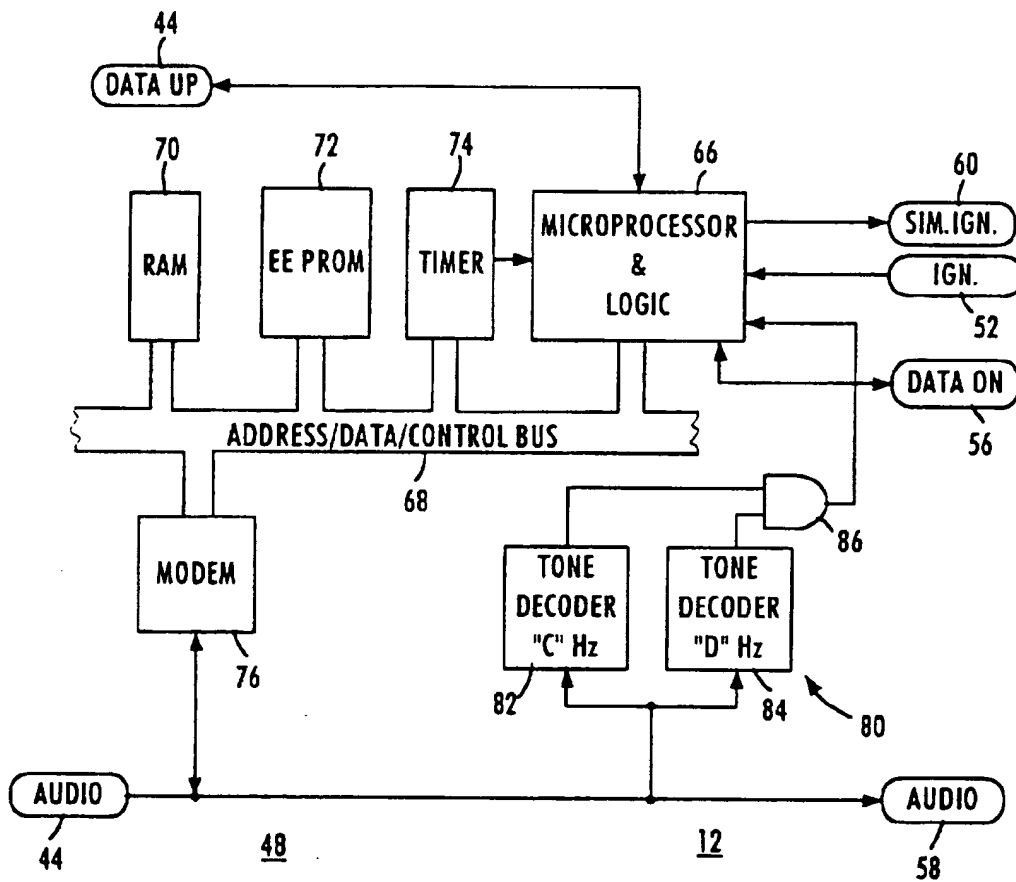


FIG. 3

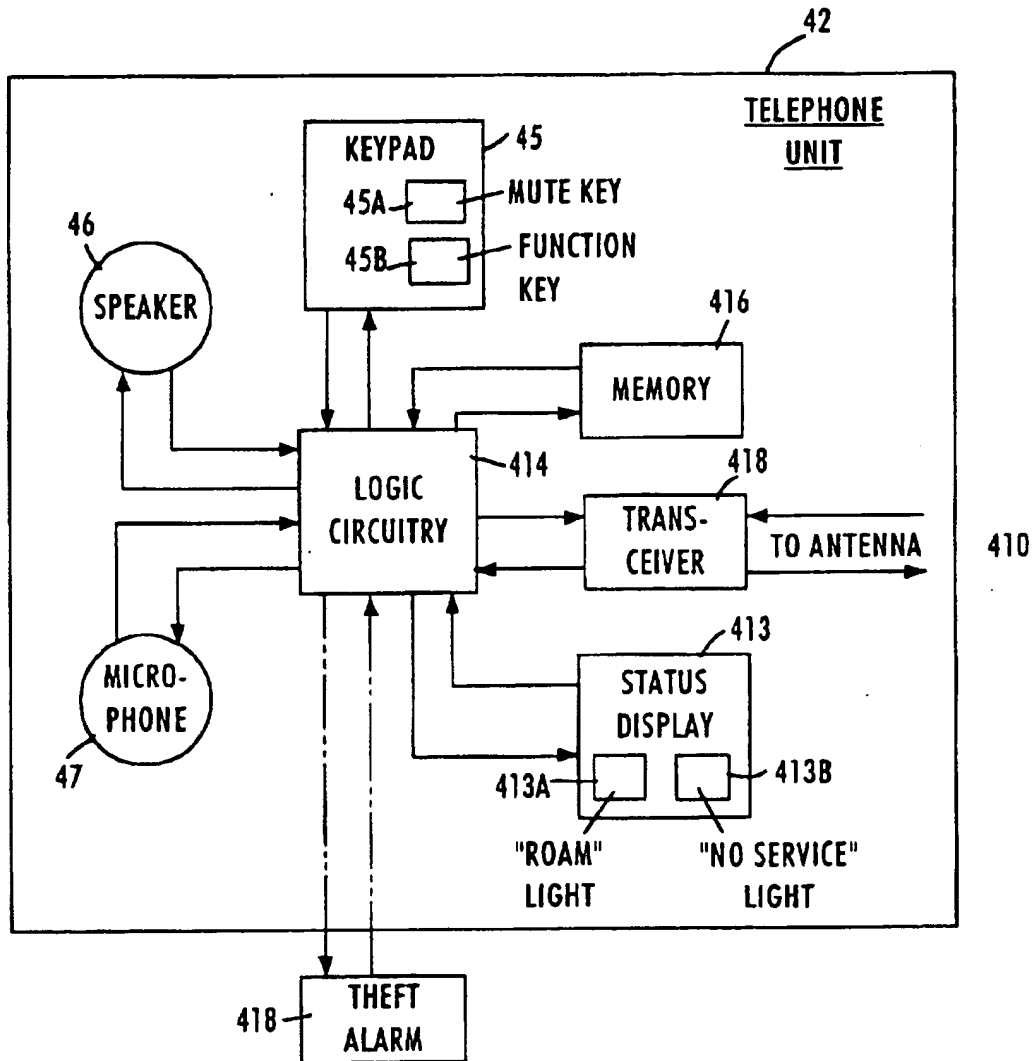


FIG. 4

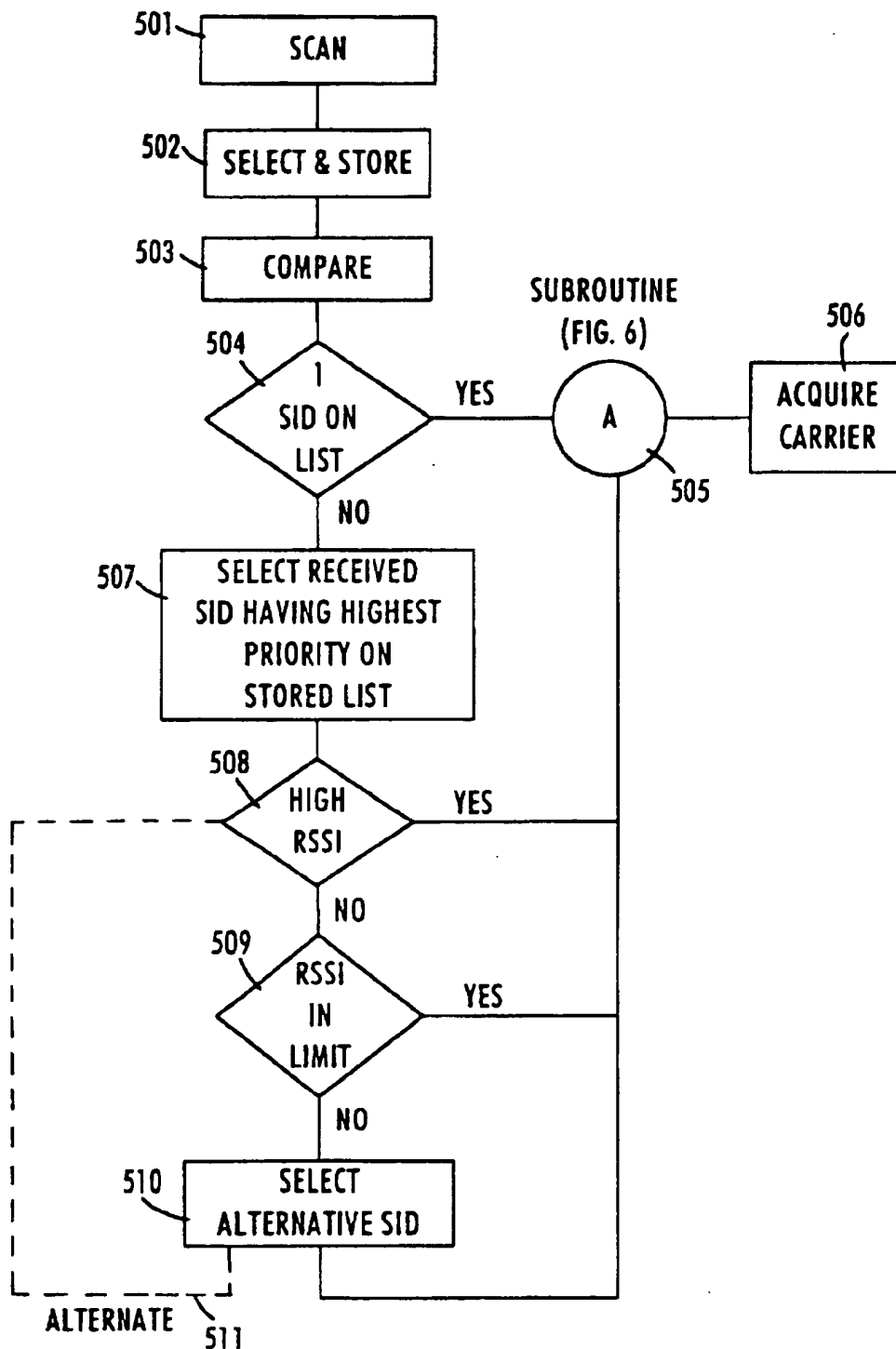


FIG. 5

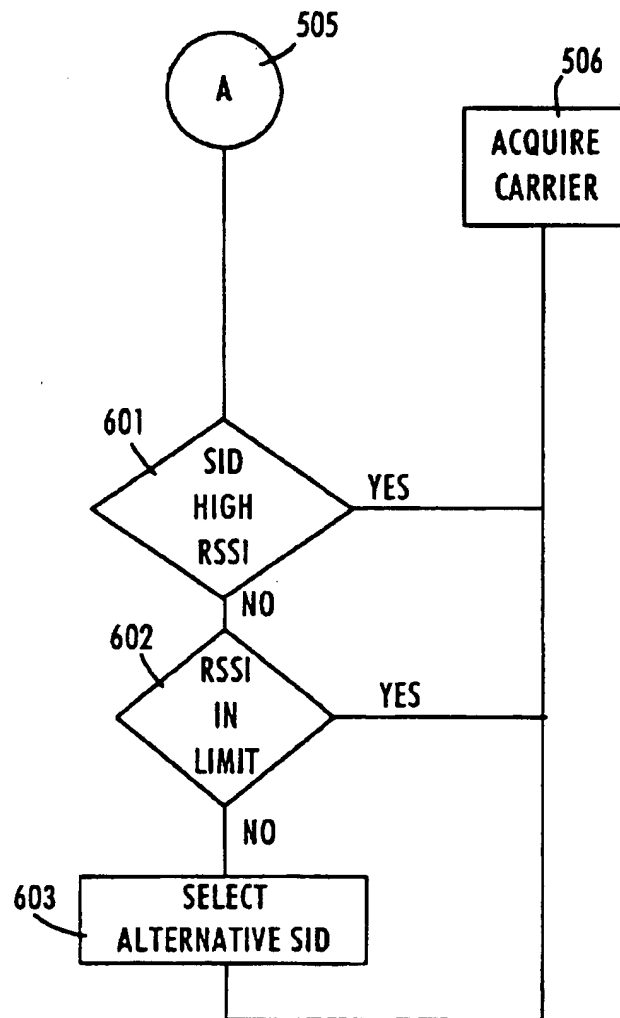


FIG. 6

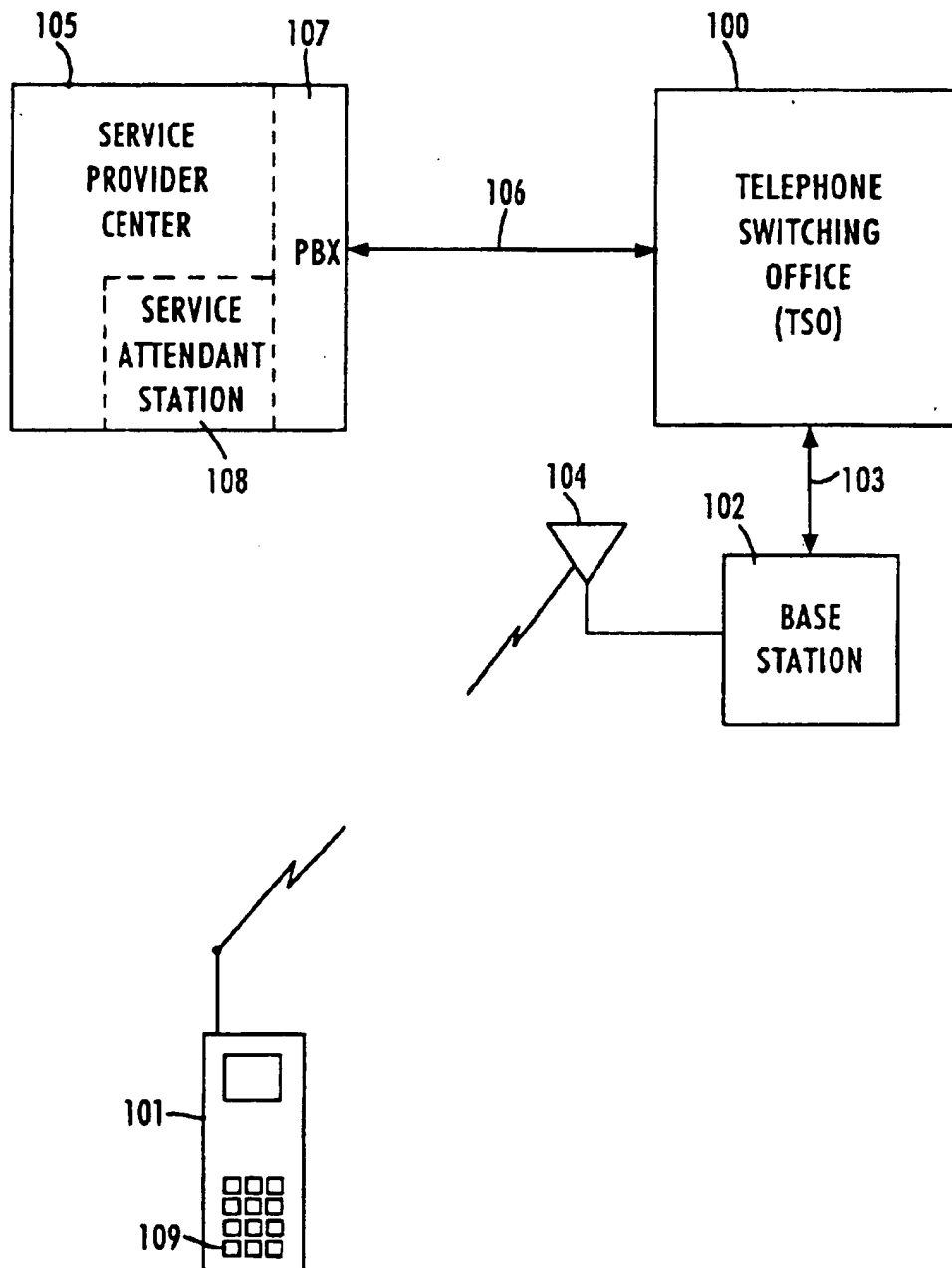


FIG. 7

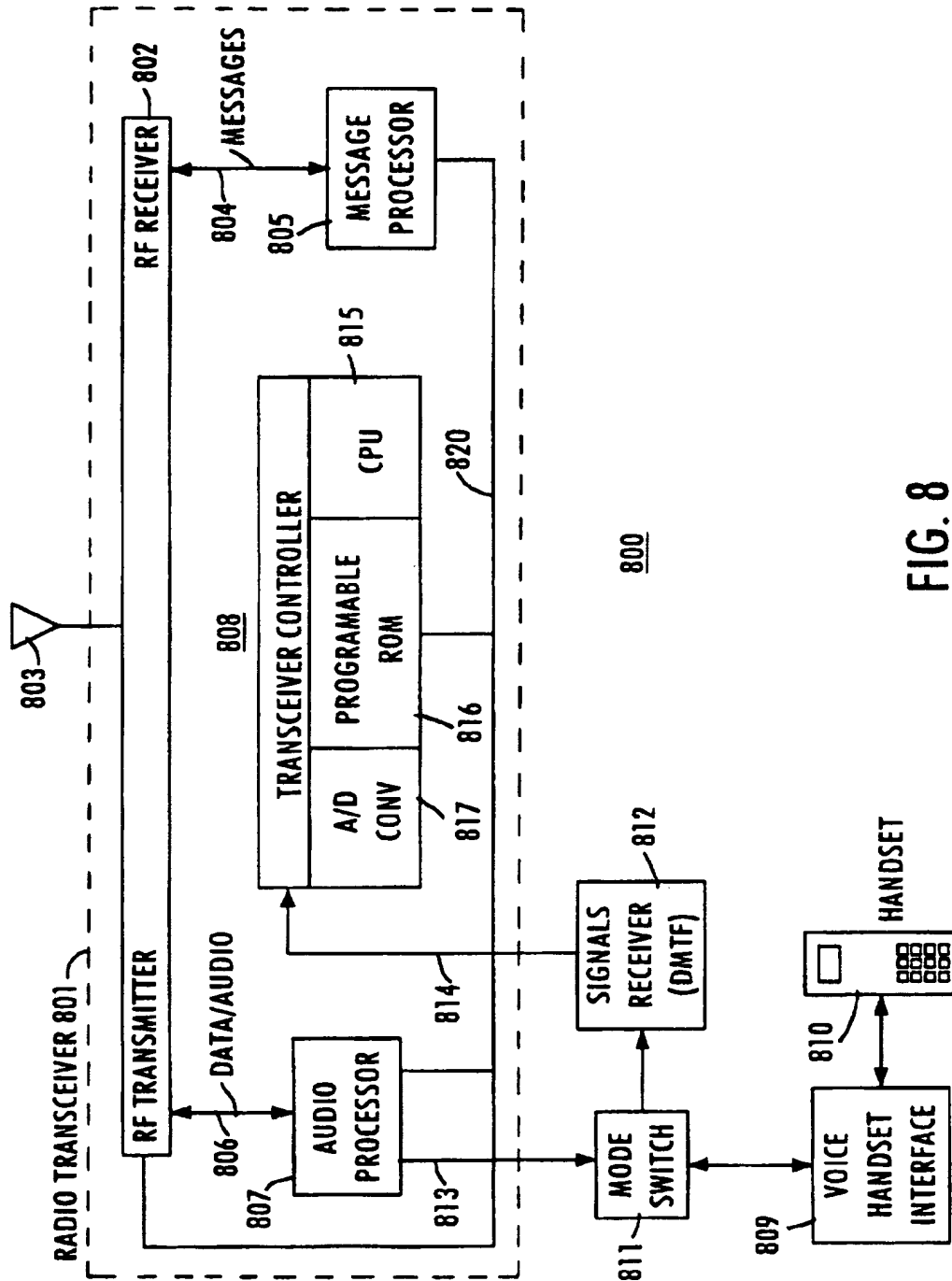


FIG. 8

UPDATING TECHNIQUE FOR DOWNLOADING NEW SYSTEM IDENTIFICATION (SID) LIST INTO A HANDSET

TECHNICAL FIELD

The present invention relates generally to subscriber cellular mobile radiotelephones (CMRs). More specifically, the present invention is related to methods for controlling CMRs by automatically downloading lists of preferred foreign cellular systems with which the CMRs can communicate.

BACKGROUND ART

Conventional cellular mobile radiotelephone subscriber units (CMRs) are capable of communicating on at least one of two independent sets of frequencies. However, a conventional cellular base system communicates on only one of these two sets of frequencies. Thus, a cellular base system may be referred to as an "A" system if it uses one set of frequencies or a "B" system if it uses the other set of frequencies. This dual-system approach to radiotelephony results from regulations which are intended, at least in part, to promote competition in providing radiotelephone services. When A and B cellular systems are both located in a single geographic area, radiotelephone service customers may choose to subscribe to either the A or B system in accordance with which system provides the best value to the customer. B systems are often referred to as "wireline" carriers because B systems are typically operated by the companies that provide wireline telecommunication services where the B systems are located. A systems are often referred to as non-wireline carriers because they are operated by companies other than the companies that operate the competing B systems. These frequency allocations are not necessarily permanent.

Each frequency set in a given cellular service area is assigned to one and only one service company. However, in different service areas the same frequency set may be assigned to different service companies (much as a television channel may be assigned to an affiliate of one network in one city and to an affiliate of another network in another city).

The home frequency set of a given telephone unit is the set of frequencies which the unit will ordinarily attempt to use. It will depend in large part on which service company is subscribed to by the telephone unit's user: if the user is a subscriber of a nonwireline service company, the user's home frequency set will be the A frequencies, and vice versa.

As will be familiar to those of ordinary skill, a frequency set typically includes paging channels and associated signalling channels, as well as voice channels. The paging and signalling channels are used for preliminary coded communications between a cellular telephone and a cell site in setting up a telephone call, after which a voice channel is assigned for the telephone's use on that call.

Each service company broadcasts a unique System Identification Number (SID) on all paging channels of the frequency sets on which it provides service in a given service area. A suitably equipped cellular telephone can thus determine which service company is providing service on a given paging channel by identifying the SID. Usually the SID contains three digits.

Receipt of a home SID is not necessarily required to be able to place a call. Many service companies have reciprocal

billing arrangements with one another, meaning that a call can be placed on a frequency associated with a non-home cellular system. However, use of a non-home service company in this manner to place a call may result in the imposition of a surcharge (e.g., a fixed surcharge or a higher per-unit rate).

Furthermore, if the non-home service company does not have a reciprocal billing arrangement with the user's home service company, as a practical matter the user may not be able to place a call at all. Even though the telephone unit is capable of establishing a connection via the carrier signal, the non-home service company's switching equipment typically will not allow the user to do anything with the connection without a way to bill the user for his or her usage. Some service companies automatically switch calls of this kind to an operator who can take down a credit card number. However, absent a billing arrangement of some kind, no call can be completed.

Cellular telephones typically include status indication displays such as status lights. The "roam" light indicates that the telephone has detected a non-home SID on a carrier signal and can make at least a connection with that company's service via the carrier signal. The "no-service" light indicates that no cellular connections are available.

When a customer subscribes to a cellular system (either an A or B system), that system becomes the subscriber/customer's home system. The company that operates a customer's home system collects billing information and bills the customer for the customer's use of the home system's radiotelephone services. Whenever a customer is operating his or her CMR on a system other than the customer's home system, the customer is engaging in an activity known as roaming. The cellular system upon which a roaming CMR is operating is viewed as a foreign system.

Customers may receive telecommunication services while roaming. However, the home system company and the foreign system company must cooperate with one another before roaming services are permitted. For example, the foreign system must transfer call record information to the home system, and the home system must bill for, collect funds for, and distribute funds back to the foreign system for the roaming telecommunication services. Accordingly, the customer must typically pay additional charges when the customer uses roaming services.

When the customer operates his or her CMR in the area covered by the CMR's home system, no serious cellular base system selection choice needs to be made. The customer will almost always want to use the home system because the charges for home-system telecommunication services will be less. On the other hand, when the customer is roaming away from the home system, a choice of whether to operate a CMR on an A or B foreign system must be made.

Conventional CMRs employ any one of several different programmable selection processes in choosing a cellular system upon which to operate. For example, a CMR may prefer an A system but accept a B system if an A system is not available. This is called an A/B selection process. Conversely, a CMR may prefer a B system but accept an A system if a B system is not available. This is called a B/A selection process. Alternatively, a CMR may select only A systems (A-Only) or only B systems (B-Only) regardless of whether a competing system is available. Furthermore, a CMR may select only the home system so that roaming is prohibited. Other selection processes may be implemented as well. A CMR will typically utilize a default selection process which is consistent with its home system. For

example, if a CMR's home system is an A system, then the CMR will typically utilize the A-Only or A/B selection processes as a default selection process.

Conventional CMRs permit alteration of the default selection process. However, this feature is not often used by customers because it is difficult to accomplish through a CMR's handset and because an intelligent nondefault selection process setting requires an understanding of cellular radiotelephony that many customers do not possess. Accordingly, providers of cellular services recognize that, for the most part, customers do not alter the default process selection setting.

The default selection process setting tends to limit any benefits that competition between A and B systems may provide while roaming. While the default setting favors the home system, at the same time it favors approximately one half of the numerous potential foreign systems over the other half of potential foreign systems. Assuming that this default setting does not change, in providing radiotelephone services to roaming customers one of each foreign area's two competing cellular systems benefits from an equipment-caused bias. As a result, the favored foreign systems need not aggressively price roaming services, and they need not be exceptionally cooperative with a roamer's home system, because it is highly probable that a roamer will use the favored foreign system regardless of cost. Consequently, roaming costs to a customer remain undesirably high.

While conventional CMRs can be configured so that the default system selection process setting is easily alterable, such configurations do not solve the problems faced by roaming customers. A typical customer is not prepared to make, or interested in making, a purchasing decision with respect to telecommunication services every time he or she is roaming. While roaming, a customer is unlikely to know the rates charged by the competing foreign cellular systems. Moreover, the rate structures may be complicated, and they may change from time to time. Thus, when a customer is roaming, he or she typically does not possess sufficient information upon which to base an intelligent foreign cellular system selection decision, even if the CMR has the capacity for such a selection. Typically the subscriber does not desire to go to the time and trouble to obtain this information, and mark the necessary alterations in the operation of the CMR.

DISCLOSURE OF THE INVENTION

An object of the present invention is to operate a CMR to select the most desirable foreign service provider with which to communicate.

Another object of the present invention is to prioritize cellular service providers with which the home service provider of a cellular subscriber as business arrangements.

It is a further object of the present invention to "weigh" operating parameters in the selection foreign cellular service providers having contractual relationships with the home service provider roaming cellular subscriber.

It is yet a further object of the present invention to enhance competition in connection with telecommunication services provided to roaming cellular subscriber.

It is an additional object of the present invention to automatically update control data, available service provider data and calling feature data to subscriber unit CMRs.

It is yet another object of the present invention to automatically update data in mobile subscriber units that is transparent to the user of the subscriber unit, and in no way hinders the normal operation of the mobile subscriber unit.

These and other objects of the present invention are achieved by a system for downloading data to radio telephone subscriber units where a control means updates a data list to be downloaded by generating a version number corresponding to the current data list. The system further includes means for broadcasting the version number to the radio telephone subscriber units which in turn compare the received version number to a stored version number of a comparable data list in each of the radio telephone subscriber units. Responsive to the comparison means for initiating in each of the telephone subscriber units will start a download of the data list based upon the results of the comparison.

In the second embodiment of the invention, the downloading is carried out on the basis of sequentially addressing each of the radio telephone subscriber units in range for the means for downloading data so that each of the radio telephone subscriber units is individually addressed for the download of the data list.

A third embodiment of the present invention is directed to a method of downloading data to radio telephone subscriber units. In this method, a data list and a version number are generated and broadcast a plurality of radio telephone subscriber units. Each of the radio telephone subscriber units compares the received version number to a version number stored in each of the subscriber units. The download of the data list is initiated to any telephone subscriber units in which the pre-stored version number does not correspond to the received version number.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a block diagram of a cellular radiotelephone system constructed in accordance with the present invention.

FIG. 2 is a block diagram of a cellular mobile radiotelephone (CMR) used in connection with the system of the present invention.

FIG. 3 is a block diagram of a remotely programmable unit (RPU) portion of the CMR of the present invention.

FIG. 4 depicts an alternative subscriber handset.

FIG. 5 is a flow chart depicting the operation of the present invention.

FIG. 6 is a flow chart depicting a sub-routine included in the operation of the present invention.

FIG. 7 is a block diagram of a comprehensive system for providing control data to a mobile radio telephone subscriber unit CMR.

FIG. 8 is a block diagram depicting another example of a radio telephone subscriber unit capable of carrying out the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

FIG. 1 is a block diagram of a cellular radiotelephone system 10 within which the method of the present invention is practiced. System 10 includes a multiplicity of cellular mobile radiotelephone subscriber unit (CMRs) 12. The precise number of CMRs 12 is not a critical feature and may range from a few to many tens of thousands. As is conventional, each of CMRs 12 is capable of communicating with either an "A" type cellular system 14 or a "B" type cellular system 16. Those skilled in the art understand that A cellular systems communicate over a first set of predetermined frequencies while B cellular systems communicate over a second set of predetermined frequencies, the first and second sets being selected so that interference between the two sets is avoided.

Cellular systems 14 and 16 each include several spaced apart cells defined by antennas 18. Communication coverage over a geographic area is achieved through frequency channel manipulation between the cells. Moreover, both an A system 14 and a B system 16 may reside in a single geographic area. When a CMR 12 has subscribed to service at one of systems 14 and 16 in a single geographic area, that system is a home system for the CMR 12. The other of systems 14 and 16 in the home geographic area, and systems 14 and 16 located in all other geographic areas are foreign systems to the CMR 12. As is conventional, when CMR 12 is operating on a foreign system 14-16, CMR 12 is roaming.

All of A systems 14 and B systems 16, regardless of their designation as a home or foreign system, couple to and operate as an integral part of the public switched telecommunications network (PSTN) 20. PSTN 20 includes all the conventional cellular radio systems, cellular switching systems, trunks, satellites, and land-wired switching systems which are well known to those skilled in this art.

System 10 also includes a remote programming (RP) host 22, which couples to PSTN 20 through at least one, but preferably many, subscriber loops 24. RP host 22 is a computer system that remotely controls the programming of CMRs 12. Generally speaking, RP host 22 periodically engages in data communication sessions with CMRs 12. During such sessions RP host 22 and a CMR 12 exchange data. Thus, data tables, timing data, predetermined telephone numbers, modes of operation flags, virtually any item of application data, and executable machine code utilized within CMR 12 may be altered as a result of such sessions.

FIG. 2 is a block diagram of one example of a subscriber unit CMR 12 that can be used in connection with system 10. CMR 12 includes a handset 30 which is coupled through a first serial data bus 32 and a first audio bus 34 to a cradle 36. Handset 30 includes a display 38 and an array of keys 40. Together, handset 30 and cradle 36 are referred to as a control unit (CU) 42. CU 42 is a conventional control unit that performs functions which are well known in the art of cellular telephony.

A second serial data bus 44 and a second audio bus 46 interconnect cradle 36 with a remote programmable unit (RPU) 48. In addition, an ignition input 52 to RPU 48 couples to the ignition of an automobile (not shown) in which CMR 12 is installed. RPU 48 regenerates serial and audio busses 44 and 46 as serial data and audio busses 56 and 58, respectively. In addition, RPU 48 has a simulated ignition output 60. Busses 56 and 58, and output 60 couple to a conventional transmit-receive unit (TRU) 62. As is conventional, an antenna 64 through which TRU 62 communicates with antennae 18 (see FIG. 1) also couples to TRU 62. RPU 48 may represent a kit which is installed between a conventional CU 42 and a conventional TRU 62 of a conventional CMR. The use of conventional CMR equipment as a platform to which remote programmability hardware is added reduces costs due to the mass production of such conventional equipment. Preferably, RPU 48 is physically mounted on CU 42.

FIG. 3 is a block diagram of typical hardware included in an RPU 48 such as that depicted in FIG. 2. As shown in FIG. 3, a microprocessor and logic section 66 is coupled to serial data bus 44 and to an internal address/data/control bus 68. Through bus 68, section 66 communicates with a random access memory (RAM) 70, a non-volatile, read-write memory 72, such as an electrically erasable PROM (EEPROM), a timer 74, and a data port of a modem 76. Those skilled in the art will understand that RAM 70 is one

example of a volatile read-write type of memory, and battery-backed-up RAM and other memory devices may serve as non-volatile read-write memory 72. An audio port of modem 76 is additionally coupled to audio bus 58, and timer 74 preferably is coupled to an interrupt input of section 66.

Microprocessor and logic section 66 generally control the operation of RPU 48. In conjunction with timer 74, section 66 maintains a clock and calendar. Moreover, power is continually supplied to section 66, timer 74, and supporting sections of RPU 48 so that data describing the date and time remain current even when ignition to a vehicle in which CMR 12 is installed is "off".

Modem 76 is a conventional modem circuit. Consequently, modem 76 recognizes audio signals on audio bus 58. Likewise, modem 76 supplies audio signals to audio bus 58. Modem 76 preferably operates at conventional data rates, such as 300, 1200, or 2400 bits per second, depending on control data supplied by microprocessor section 66. Communicated data and control data, such as carrier detection, are communicated to and from microprocessor section 66 through bus 68. On the other hand, ring detection is carried out by microprocessor section 66 monitoring data commands on serial data bus 56.

Section 66 senses the state of ignition signal 52. In addition, section 66 senses the state of an output from a signal detection circuit 80. Signal detection circuit 80 includes first and second tone decoders 82 and 84, respectively. Inputs of tone decoders 82 and 84 are coupled to audio bus 58, and outputs of tone decoders 82 and 84 are coupled to inputs of a logic element 86, which performs a logical AND function. The output of element 86 serves as the output of signal detection circuit 80 and is coupled to a sensing input of section 66.

Signal detection circuit 80 is configured to detect a predetermined login audio tone. In the preferred embodiment, this login tone includes two predetermined frequencies, labeled as "C" and "D" in FIG. 3. Frequencies C and D are selected so that the login tone is as unique as possible within normal telecommunication.

The method of the present invention is practiced, at least in part, by RPU 48. As discussed above, CU 42 and TRU 62 (see FIG. 2) are provided by conventional nonremotely programmable cellular radiotelephone equipment. Specifically, in the preferred embodiment, a cellular telephone manufactured by the OKI corporation as model EM-23 serves as CU 42 and TRU 62. Generally speaking, microprocessor and logic section 66 of RPU 48 practices this method by executing programming instructions stored in memories 70-72. This method involves, at least in part, the processing of data to control the operation of system 10 (see FIG. 1). Some of the specific processing tasks performed by the preferred embodiment are directly related to the data messages and data formats dictated by the above-mentioned OKI model EM-23 cellular telephone. However, other conventional cellular telephones have similar or identical types of data messages and can be adapted by those skilled in the art for use in connection with the present invention.

Another illustrative example of a microprocessor-based telephone system operated in accordance with the present invention is described below. This example uses an automobile cellular phone as an example, but it will be understood by those of ordinary skill that the invention can be implemented in virtually any telecommunications system.

FIG. 4 depicts a typical automobile cellular telephone unit 42 having a unique mobile identification number (MID)

on the pre-stored preferred SID list, a determination of "YES" is made at step 504 and the process continues to point A at which sub-routine 505, as depicted in FIG. 6 can be carried out.

After sub-routine 505 is carried out, the subscriber unit acquires a carrier frequency corresponding to the single received SID as depicted at step 506. Once the carrier (on a control frequency) is acquired, the handset initiates registration with the system provider corresponding to the single SID resulting from the comparison of the received SIDs with a preferred SID list. It is noted that sub-routine 505 at point A is optional and can be used or deleted depending upon the constraints of the overall system as well as the priorities of the system operator.

There are other circumstances under which a plurality of positive comparisons will take place at step 503, resulting in a plurality of received SIDs from which a subscriber unit must choose. There are a number of ways of making this choice. In the conventional art, usually the first received SID found in the first positive comparison is selected as the service provider with which the subscriber handset will register. This approach can be used with the present invention as long as each frequency band is scanned and at least one received SID from each band is stored in the subscriber unit.

The present system provides techniques that ensure greater chances of successful communication being carried out between the subscriber unit and the selected service provider. One such technique is the assignment of priority within the pre-stored preferred SID list in the subscriber's station. Such priority could be based upon contractual considerations. However, this is not necessary. Rather, priority can be based upon RSSI or other system characteristics of the service provider that might further enhance the quality of communication between the subscriber unit and the system provider, as well as enhance communication between parties in communication with the subscriber unit via the service provider. One criterion for such prioritization can be the selection of a particular band such as the PCS bands under certain conditions. However, other characteristics of particular service providers can also be the basis of such prioritization, as long as the result is communication superior to that of other service providers accessible by the subject subscriber unit. Whether the criterion for priority be contractual or characteristic of a communication system, one of the received SIDs is selected at step 507 to be that which is most preferred for registration with the subscriber unit.

At step 508, the RSSI of the selected SID having the highest priority is compared to the RSSI of each of the received SIDs having a positive comparison with the pre-stored SID list in the subscriber unit. If the selected SID has the highest RSSI of this group, the process moves to point A and the option of carrying out sub-routine 505. If the selected SID is unchanged by sub-routine 505, the control frequency corresponding to a service provider having the selected SID is acquired by the subscriber unit and registration carried out with that system provider.

If the selected SID does not have a highest RSSI of the received SIDs having a positive comparison with the pre-stored preferred SID list, a biasing process is conducted at step 509. The biasing process is used to favor a selected SID having a higher priority but a lower RSSI (or other signal characteristics) than other received SIDs found on the preferred SID list. One technique is indicated at step 509 and is constituted by a determination that the selected SID is within a predetermined tolerance "window". This "window" is

based upon a predetermined difference between the RSSI of the selected SID and the highest RSSI of any received SID found on the priority list. Since the whole purpose of this comparison is to bias the system in favor of staying with a higher priority SID based on the preferred SID list, the size of the "window" or of any other threshold can be determined by well-known statistical techniques.

However, such techniques are not necessary. A system operator could simply assign some arbitrary value based upon his or her own judgment reflecting a trade off between signal strength (call quality) and predetermined priority for selected system providers. If the RSSI of the selected SID is within the predetermined limits at step 509, the process moves to point A for the option to undergo sub-routine 505 as illustrated in FIG. 6. As previously stated, this sub-routine can be bypassed at the discretion of the system operator. If the selected SID remains unchanged after point A, carrier acquisition of a control frequency for the selected SID is conducted at step 506 as previously described.

If the RSSI of the selected SID is not within the predetermined limits used at step 509, the process moves to step 510 for the selection of an alternate SID. As indicated in FIG. 5, the alternate SID is selected and the routine moves to point A, and from there to the acquisition of an appropriate carrier frequency. The selection of the alternate SID can be based upon the received SID on the preferred SID list having the highest RSSI. An alternate routine is also possible as indicated by alternate 511 on FIG. 5. In this alternate, the alternate SID is based upon a level of priority of a received SID as determined by the priority of the SIDs on the preferred list stored in the subscriber unit CMR. Taking this alternative, a determination is made at step 508 if the new (alternate) SID has the highest RSSI (of all received SIDs found in the preferred SID list). The process of steps 508, 509 and 510 is repeated as before.

FIG. 6 is a flow chart depicting an optional sub-routine that can be carried out at point A of the FIG. 5 flow chart. Instead of carrying out the sub-routine, the SID selected in the flow chart of FIG. 5 can be the SID with which the roaming subscriber unit registers by acquiring a control carrier at step 506. However, there may be circumstances under which there is a wide disparity between the RSSI of received SIDs found on the preferred SID list and the RSSI of received SIDs not found on the preferred list. Consequently, some balancing must be done between the desire to use a preferred service provider and the necessity of ensuring high quality communication. This balancing has already been partially addressed by some of the steps in the flow diagram of FIG. 5. However, this is limited to a comparison of the RSSI of those received SIDs found on the preferred SID list. Other received SIDs may have much higher signal strength readings, making them better candidates for completion of a call even though the available rates are not as low as those from service providers on the preferred SID list.

At step 601, the RSSI of the selected SID is compared with that of all the other received SIDs to determine if the RSSI of the selected SID is the highest. If this is the case, then the control carrier of the service provider associated with the selected SID is acquired by the subscriber unit and registration carried out. If, on the other hand, the selected SID does not have the highest RSSI of all of the received SIDs available to the subscriber terminal, a comparison will be made at step 602 between the RSSI of the selected SID and that of the available SID having the highest RSSI value. This step can be conducted in the same manner as done at step 509 in FIG. 5. The selection of a "window" or a

stored in a suitable location such as an electrically erasable programmable read-only memory (EEPROM, not shown). Telephone units of this kind are well known in the art and are described here only in sufficient detail to aid understanding the invention.

The telephone unit 42 includes a handset 44 having a keypad 45; equivalently, the keypad 45 could be located separately from the handset. Also included in the telephone unit 42 are a speaker 46 and a microphone 47, shown as being mounted within the handset 44 but either or both of which could equivalently be mounted apart from the handset, either separately (e.g., in a telephone operator's headset or in wall mountings), or approximately together (e.g., in a walkie-talkie or speakerphone configuration).

A transceiver 48, ordinarily built into the telephone unit 42, exchanges signals via an antenna 410 with a Mobile Telecommunications Switching Office (MTSO) typically via radiotelephone signals relayed by one of several cell sites 11 that are in turn connected with the MTSO via a landline. The MTSO is ordinarily connected with a telephone company switching unit via a high-capacity landline or similar connection.

A status display 413 shows the status of the telephone unit 42. The status display 413 typically includes a NO SVC indicator to show that no cellular telephone service is available; and a ROAM indicator to show that the telephone unit 42 is outside its usual service area.

The transceiver 48 and antenna 410 are shown as being separate from the handset 44, but either or both could equivalently be built into the handset. The MTSO could equivalently be another telephone or similar unit if both telephones had appropriate signalling, switching, and call processing capabilities.

Those of ordinary skill having the benefit of this disclosure will appreciate that the signal exchange may utilize any of a wide variety of transmission systems that are equivalent for purposes of this description. These include, for example, radio, electrical-type wire (such as telephone landlines), modulation of light beams (e.g., in fiberoptic networks or laser beams), and so forth. The signal exchange may use one or more of these media alone or equivalently in combination. Whether specific components such as the antenna 410 are needed for a given implementation of the invention will depend in part on the transmission system selected for implementation.

The operation of the telephone unit 42 is controlled by logic circuitry 414. The logic circuitry 414 may be implemented in the form of a microprocessor which executes program statements stored in a storage device such as a read-only memory, or equivalently by discrete logic components or one or more custom semiconductor chips.

Those of ordinary skill will appreciate that a sequence of numbers to be dialed by the telephone unit 42 is processed by the logic circuitry 414 generally as follows, both in the prior art and in connection with the invention. Under control of the logic circuitry 414, the transceiver 48 transmits a cellular control signal to a cell site 411 over a signalling channel. The control signal includes a request that the MTSO dial a specified telephone number and assign a voice frequency or channel for use by the telephone unit 42.

The telephone unit 42 includes a read-write memory 416, accessible to the user and whose contents will not be affected by telephone power-downs of ordinary duration. For example, the memory 416 may equivalently comprise an EEPROM programmable by the user, a CMOS memory chip, or a conventional RAM with an independent power

supply, any of which may possibly be implemented as part of a custom semiconductor chip.

It will be understood that telephones used in typical cellular systems are capable of generating both dual tone multi-frequency (DTMF) signals (DTMF signals produced by Bell telephones are referred to by the "Touch-Tone" trademark) and EIA standard IS-3-D cellular control signals.

The present modified handset used to carry out the present invention can be programmed to handle both registration and hand-off in accordance with the operation depicted in FIGS. 5 and 6, or can be arranged to accommodate variations which would occur to those skilled in this art. It is noted that FIGS. 5 and 6 depict one example of an optimal, comprehensive system that it preferably applied in the registration operation of a roaming subscriber unit.

The present invention operates using the aforementioned modified handsets or any equivalent thereof in accordance with the process depicted in FIGS. 5 and 6. As previously stated, the SID is part of the overhead message that is sent to the mobile subscriber unit when it is powered up, and periodically thereafter. Normally when a mobile subscriber unit CMR is powered up, it scans the wireless systems operating within proximity to the mobile subscriber unit, taking signal strength readings in the various available frequency bands (cellular A and B, and PCS). This step is depicted at 501 in FIG. 5.

At step 502, at least one SID for each of the bands, as well as the corresponding Received Signal Strength Indication (RSSI) is stored at the subscriber unit. This function is preferably carried out in RAM 70 of FIG. 3 or in the logic circuitry 414 of FIG. 4. Normally only a single SID and its RSSI are recorded for each of the bands. However, on a third or C band that is normally dedicated to Personal Communication Systems (PCS), at least two SIDs and their RSSIs will be stored by the subscriber unit.

The present invention also encompasses the capability of selecting and storing more than one SID for each of the bands scanned. One example of such a situation is in areas at the interface between two service providers. Another example is found in hand-off situations. In both such situations, the two strongest signals for each of the scanned frequency bands will be selected and stored by the subscriber unit.

At step 503, the SIDs of the scanned signals having been selected and stored are compared with a list of SIDs for preferred system providers. Such system providers usually have a special contractual relationship with the home service provider of the roaming subscriber so that the subscriber receives preferential treatment, normally in the form of lower usage rates. The list is normally pre-programmed into either a special memory such as EEPROM 72 (FIG. 3) or a microprocessor and logic circuitry 414 (FIG. 4). However, storage of the preferred SID list corresponding to preferred service providers can be carried out in any manner that would occur to those having skill in this art. The preferred SID list can also be modified or updated in any practical manner that would occur to one skilled in this art. The comparison operation is a simple logic operation meant to identify the received SIDs corresponding to those on the preferred SID list stored in the subscriber unit CMR. This comparison can be as extensive as necessary depending upon the number of received SIDs and the full extent of the pre-stored preferred SID list.

At step 504, a determination is made as to whether one of the received SIDs is on the preferred SID list stored by the subscriber unit. If only a single received SID is found to be

"threshold" depends upon the system operator's balancing of the desire for a higher priority service provider and the need for the highest quality communication. If the selected SID is within the tolerance ranges dictated for the step at 602, then the control frequency carrier of the system provider corresponding to the selected SID is acquired and registration carried out.

If, on the other hand, the RSSI of the selected SID is not within the limits set at step 602, an alternate SID must be selected as indicated at step 603. Based upon the process carried out in FIG. 5, the selected SID is assumed to be that having the highest RSSI of all of the received SIDs on the preferred SID list stored in the subscriber unit. Consequently, the only alternatives available for superior call quality will be received SIDs not found on the preferred SID list stored in the subscriber unit. Since there is no priority among the received SIDs not on the preferred SID list, the SID having the highest RSSI will be selected to ensure the highest call quality. Consequently, at this point, the selection of an alternate SID will be limited to a single choice.

It is noted that with the proper selection in criteria applied at step 502 in FIG. 5, steps 509 and the entire sub-routine of FIG. 6 can be eliminated. This would require that only those signals that have a sufficiently high RSSI for high quality communication will be considered, thereby obviating additional checks of RSSI for a selected SID. It is further noted that the use of steps 509 and 602 for additional RSSI comparison is necessitated only when there are a plurality of acceptable SIDs found on each of the frequency bands. Normally this is not the case in the A and B bands. The C band which is expected to be dedicated to PCS use, on the other hand, will provide a plurality of SIDs so that at least two SIDs will be selected and stored (at step 502) for the PCS band. It is further noted that there may be more than one PCS band, and each of these bands will provide at least two SIDs to be selected and stored at step 502. As previously stated, if the threshold parameters at step 502 are set high enough, even the PCS bands will normally not provide more than one candidate SID for selection and storage. Such threshold parameters are adjustable based upon the traffic, band allocation and other parameters known to the system operators and designers. The thresholds throughout the entire process depicted in FIGS. 5 and 6 are variable, and as previously stated, can actually be used to eliminate some of the steps as being redundant. The key to the operation of the present invention is the use of at least one signal from each of the bands for selection and storage, and later comparison to the preferred SID list.

While registration of a roaming subscriber unit is normally limited to the selection and storing of a single SID from each of the available bands during registration (except at the boundary between service providers), this is not the case for hand-off occurring at the boundary between cell site base stations. Because of this interface, there will be more than one strong signal on each of the bands. Consequently, it is necessary for the system to select and store the two strongest signals from each of the available bands.

The process depicted in flow charts of FIGS. 5 and 6 can be used to bias hand-off from a preferred service provider to a non-preferred service provider. Such biasing would take place at step 506 (FIG. 5). This biasing would inhibit hand-off from a weakening preferred service provider to a non-preferred service provider having a much stronger signal. As previously stated, the ratio between the two signals could be the key factor for determining when the delayed hand-off should finally take place. Thus, a modified version

of FIG. 5 could be employed as part of the overall hand-off sequence. The SIDs available for hand-off would be selected and stored. The received SIDs would be compared to the stored preferred SID list to determine if a preferred SID was available for hand-off. A preferred SID could be selected based upon signal strength or priority of the stored SID list. A final comparison of the RSSI of the selected SID could be made to that of the strongest available SID. In this step, the biasing factor could be applied balancing the desire to use a preferred SID against the necessity for high quality signal characteristics. Based upon this last evaluation, either the selected preferred SID can be used as a hand-off target, or the strongest non-preferred SID can be used. In the latter case, hand-off from a preferred SID to a non-preferred SID can be delayed based upon differences in signal strength or any other factor that could be derived through normal statistical analysis. Such a statistical analysis is not necessary since the factor could be based solely on the judgment of the system operator.

It is significant to note that the present invention can be used to accommodate virtually any contractual arrangement between service providers, encompassing a wide range of system provider status and priority. These priorities can be balanced against measured signal parameters based upon virtually any criteria selected by the system operator. The purpose of any biasing done in this balancing between the two factors is done with the purpose of maintaining acceptable communication quality while keeping the price to the subscriber as low as possible.

It is noted that the operation of selecting the most appropriate available service provider based upon the pre-stored preferred SID list can be manually negated. This is most easily done through keypad 45 (FIG. 4). However, the manual override control is not limited to the depicted keypad. Rather, any control device occurring to one skilled in this art can be used with a handset modified in accordance with the present invention.

Because contractual relationships between system providers change, changes in the preferred SID list stored in the subscriber units will be necessitated from time to time. As previously described, updates of the preferred SID list can be entered manually using the keyboard on the subscriber handset. However, this process requires instructions from the service provider as well as a concerted effort on the part of the subscriber to make the necessary changes. Further, a subscriber does not normally know when to contact the service provider to receive updates in a timely fashion. It is also noted that a system provider may wish to download data in addition to that contained in the preferred SID list to individual subscriber units. Consequently, manual downloading of the preferred SID list and any accompanying data is inappropriate.

To better serve the subscriber, the updated preferred SID list should be automatically downloaded from the service provider to the subscriber handset as soon as the changes to the SID list have gone into effect. Further, for the convenience of the subscriber, the downloading operation is best conducted in a transparent manner, that is, the subscriber is unaware when the operation is being carried out. The only indication that need be made to a subscriber is a display of the most recent version of the updated preferred SID list, provided when a manual request is entered by the subscriber using the handset keyboard.

In order to carry out the aforementioned service of the subscriber, it is necessary to establish a wireless bidirectional communication path between the subscriber unit and

a remote control center. The subscriber unit is activated when it is to receive the updated preferred SID list, as well as other data, over the communication path. This path can be constituted by both wireless and landlined links, depending upon the characteristics of the service provider. The subscriber unit can be selectively activated by the service provider communication system, or can receive the updated preferred SID list by way of a general broadcast. Authorization for carrying out this communication can be initiated within the communication system of the service provider, or can be initiated by the subscriber through the subscriber unit handset. In either case, identification (of the subscriber unit) is necessary to carry out a "handshake" process, assuring that the proper subscriber unit is receiving the proper information from the service provider communication system. One method for placing the subscriber unit in the program mode (to record the updated preferred SID list) is receipt of the predetermined sequence of tone signals using a Dual Tone Multi-Frequency (DTMF) receiver in the subscriber unit handset.

Shown in FIG. 7 is a schematic representation of a wireless communication configuration which illustratively includes a telephone switching office (TSO) 100 which is adapted to link a wireless telephone set 101 into a regional or nationwide telephone network (not shown). A base station 102, coupled to the TSO 100, via a bidirectional communication link 103, is arranged to be in radio frequency communications with the wireless telephone set 101 via a radio frequency antenna 104. Also shown in schematic form, is a communications service provider center 105 adapted to be coupled to the TSO 100 via another bidirectional link 106. The service provider center 105 includes, inter alia, a telephone private branch exchange (PBX) 107, and a service attendant station 108 coupled to the PBX 107. It is well within the spirit and scope of the present invention that the wireless telephone set 101 may include a fixed wireless telephone station, a mobile/cellular telephone set, or a cordless-type telephone set.

Normally a mobile wireless telephone set, such as disclosed herein, may not initiate and complete radiotelephone calls until it is registered with and authorized for service by a service provider. All regular radiotelephone communication channels are blocked to unauthorized callers who are not registered and authorized for service. Virtually all service providers however do provide continuously unblocked service channels for permitting mobile wireless telephone sets to communicate with the service center without having prior registration and authorization. This is typically a 611 number and may be accessed by any handset whether it is presently authorized or not.

The principles and features of the present invention shall be hereafter described in connection with FIG. 7. Upon the purchase or lease of the wireless telephone set 101, a prospective subscriber would be assigned by the vendor or lessor a valid wireless (cellular) telephone number which typically would include an area or regional code number followed by a station number. In order for the subscriber to be able to use the wireless (cellular) telephone set 101, a telephone service provider or reseller, of the subscriber's choice, must authorize such use by programming the set 101 so that it is identifiable within the wireless telephone network as an authorized and legitimate wireless service subscriber/user.

One method of programming cellular subscriber unit 101 is achieved by having the subscriber dial, out of the set 101, a predetermined service center number to first establish a communication path over the unblocked service channel

with the service provider center 105 via the radio antenna 104 and base station 102, the bidirectional link 103, the TSO 100 and the other bidirectional link 106. Once the communication path is established between the telephone set 101 and the service provider center 105, the subscriber/user can verbally, or by means of the telephone set dial, convey to an operator at the service attendant station 108 any requested subscriber-specific information. In accordance with an illustrative embodiment, the telephone set 101 is equipped with a program activating key 109 adapted to bridge an audio signal receiver (not shown), which is located within the telephone set 101, onto the then currently established communication path with the service center 105. In turn, the operator at the attendant station 108 would bridge an audio signal transmitter located at the center onto the communication path. The foregoing in effect couples the transmitter at the center 105 with the telephone set signal receiver so that the service operator can remotely enter information directly into the set 101.

As mentioned above, the information intended to be entered and stored in the telephone set 101 is specific to the subscriber owner or lessee. In the case of cellular mobile communication services, such information is referred to as Number Assignment Module (NAM) designation parameters. A sample of such NAM designations that can be remotely downloaded into the telephone set 101 are listed in the following table:

System Identification	00022
Telephone Number	2013866366
Access Overload Class	06
Group Identification	10
Initial Paging Channel	0334
Security Lock Code	6366
Local Use Flag	1
A/B System Selection	1
Min Mark Flag	1

The service operator at the station 108 can either use a telephone keypad as means for generating and transmitting the above NAM designation parameters, or alternatively can enter the above-listed information into a data terminal, e.g. a computer, that is coupled to a signal transmitter, e.g. a DTMF generator. In the above example, a total number of NAM characters to be transmitted includes 30 digits, with each digit having a value of 0 through 9. With the addition of an initial character to denote the beginning of transmission (e.g. "*"), an ending character to indicate the end of transmission (e.g. "#"), and, for example, a three-digit cyclic redundancy check (CRC) coding segment, the information is transmitted as follows:

*000222013866366061003346366111#BBB

wherein BBB is a CRC 8 checksum byte. Once the above information is received, detected and stored in the telephone set 101, the latter is switched back into normal (i.e., voice) telephone service operation at which point the subscriber user is informed by the service operator that the telephone set 101 is fully programmed and ready for use.

Another example of a subscriber unit handset configured to carry out the downloading operation of the present invention is depicted in FIG. 8. The subscriber unit CMR includes a radio transceiver portion 801 which includes a radio frequency receiver/transmitter 802 coupled to an antenna 803 and adapted to receive and transmit signals from and to a base station, e.g. a mobile cell site, or another wireless telephone. Coupled to the receiver/transmitter 802,

via a bidirectional message connecting lead 204, is a processor 805 capable of receiving and processing system message-type signals. Also coupled to the receiver/transmitter 802, via another bidirectional lead 806, is a processor 807 adapted to process data signals as well as audio signals originating or received at the wireless telephone 800. Audio and data signals present on lead 806 are those signals intended for and derived from the antenna 803.

Within the radio transceiver 801, a controller 808 is coupled to the message processor 805 and the audio processor 807, via a control bus 820, which is also coupled to the receiver/transmitter 802. A voice handset interface circuit 809 interconnects the audio processor 807 and a telephone handset 810. In accordance with one illustrative embodiment, interposed between the voice handset interface 809 and the radio transceiver 801 is a mode switch 811, which in turn is coupled to a signals receiver 812. The latter is coupled via lead 814, to the transceiver controller 808. During the remote programming, or NAM designation parameters downloading, of the telephone set 800, the mode switch 811 diverts signals received at the antenna 803 and present on output lead 813 of the audio processor 807 to the signals receiver 812. The signals receiver 812 may be selected among known commercially available receivers, such as, for example, the Hitachi HD404678 4-bit microprocessor with an integral DTMF receiver. In the case where the programming signals out of the audio processor 807 and present on lead 813 are in digital form, the signals receiver 812 couples such digital signals to the controller 808 wherein an internal controller processing unit 815 directs such digital information for storage in a memory circuit within the controller 808, such as, for example, permanent read-only memory 816. Alternatively, if the programming information received at the antenna 803 is in the form of a sequence of tone signals, the receiver 812 (which in such case would be a tone signals receiver) would connect such signals to an analog-to-digital converter 817 located within the controller 808. The digital output signals generated by the converter 817 would next be stored in the memory circuit 816 under the control of the processing unit 815.

One technique for carrying out the updated preferred SID list download to subscriber units would be to send the update information as part of the normal overhead message that all mobile units receive during their normal operation. However, this technique would require changes in the cellular industry standards. This is a long and involved process and may not be considered feasible for the near future. The overhead message can also be used to direct subscriber units to tune to another frequency capable of handling the data content of the updated preferred SID list download.

This could be accomplished by inserting a character into the normal overhead message. Such a character would be indicative of the current version of the preferred SID list. The subscriber unit CMR to compare this version of the SID list with the current version stored within the subscriber unit. If the two versions are identical, the subscriber unit need take no further action. However, if the versions do not match, this difference is indicative that a new download of the updated preferred SID list must be made. The presence of a character representing the current version of the updated SID list could also signal the subscriber unit that another overhead message will be transmitted strictly for the purpose of updating the preferred SID list. For example, the additional overhead message could contain information directing the mobile subscriber to tune to a voice channel for the updated preferred SID list download.

Generally, the download of the updated preferred SID list is conducted within the geographic region served by the

home service provider. While it is possible to update the SID list of a roaming subscriber, this operation requires additional manipulations resulting in a more complex operation. Downloading within the geographic area served by the home service provider is also preferable since the home service provider may customize the operation of local control. If a subscriber uses a Group ID Mark (GIM) of ten, the subscriber's handset will only recognize local commands at the least significant ten bits of the received SID matches the least significant ten bits of the pre-programmed SID stored in the handset. This implies that local control will typically work only for home mobile subscribers, or those which meet the above-mentioned criteria for roamers.

The protocol for downloading updated preferred SID lists follows standard registration protocol in which current word links for local control are as follows. The Forward Control Channel (FOCC) is sixteen bits; the Reverse Control Channel (RECC) is five bits; the Forward Voice Channel (FVC) is five bits; and the Reverse Voice Channel (RVC) is five bits. Normally these fields are error-corrected.

In a first version of the present invention for downloading an updated preferred SID list to subscriber units, the version number of the current SID list is maintained in a central controller (such as service provider center 705 in FIG. 7). During the downloading operation, the current version number is broadcast over the FOCC. If a mobile unit recognizes that its own pre-stored SID list is older (a lower version number) than that of the version being broadcast, the mobile unit will initiate a SID list download over the RECC. The system (preferably through a base station such as 702 in FIG. 7) will complete a call to the mobile subscriber unit, informing that unit that the SID table is being downloaded through a voice channel. The system then sends the mobile subscriber forward over the FVC. The first five bit word uses four bits for the version number of the current preferred SID list being downloaded to the mobile subscriber. Normally, the most significant bit is set to "one" in order for an addition to be made to the stored SID list in the mobile subscriber unit, and set to "zero" for a deletion from the SID list stored in the mobile subscriber unit. Normally the next three words will be the fifteen bit SID to be added or deleted. After each forward transfer, a mobile subscriber unit sends a code over the RECC to signify that correct completion of the transfer has occurred. If the four words are not properly received by the mobile subscriber unit, the mobile subscriber unit sends a code requesting re-transmission over the RECC.

After all the SIDs are downloaded from the communication system to the mobile subscriber unit, the system sends a code over the FVC to the mobile subscriber unit signifying that transmission is ended. The mobile subscriber unit then updates the version number of its current preferred SID list, confirming the end of transmission status over the RVC.

In the aforementioned version of the present invention, the overhead message containing the latest version number of the preferred SID list is broadcast to any mobile station in range of the base station making the broadcast. It is noted that the base station broadcasts are controlled by a mobile telephone switching office 700 (in FIG. 7). However, the present invention is not limited to this technique. In an alternate embodiment, each of the mobile subscriber units in a geographic area controlled by a MTSO is individually addressed to receive the most recent version of the preferred SID list. The MTSO keeps tracks of each of the subscriber stations within its geographic area, and thus, can keep track of each subscriber station that has been provided with the most recent version of the preferred SID list. While a record can be kept in either the MTSO or each of the base stations

of each of the subscriber units within the system having the latest version of the preferred SID list, this is not necessary. Rather, in the alternative, each of the base stations can automatically continue to update each of the subscriber units within its geographic area. The subscriber units can be addressed sequentially for the download, and the sequential address repeated once the entire list of subscriber units has been addressed. Records of subscriber units with updated preferred SID lists need not be kept.

One way of addressing each of the individual subscriber units is through the technique of "alert and flash" carried out on a control channel or as part of the overhead message. The "alert and flash" message contains information regarding the voice channel to which the subscriber unit is tuned to receive further data. The "alert and flash" message also includes other information regarding the content of the data which is to be downloaded over the voice channel. Such data could contain the latest version number of the preferred SID list. If that particular subscriber unit has already received that version, a comparison within the subscriber unit handset will indicate that it is not necessary to tune to the voice channel to receive the download. Consequently, the subscriber unit is forewarned that it is not necessary to tune to the voice channel for the data download. It is noted that the "alert and flash" technique can be used with both analog and digital handsets. The operation of the present invention is not limited to either type of handset that is meant to encompass any form of subscriber unit that can carry out the selection of a service provider based upon a predetermined SID list which is automatically downloaded on a timely basis from a communication system.

In the alternative, the individual subscriber unit can receive instructions specified only for that unit to tune to a traffic or a voice channel. Upon tuning to the required channel, the subscriber unit will receive an "alert and flash" signal indicating the nature of the data to be downloaded into the subscriber unit. As previously described, the subscriber unit can use the data in the "alert and flash" signal to determine if a download is appropriate or not. The latest version of the preferred SID list is only one example of such data contained in the "alert and flash" signal.

Other types of data can be used to allow a subscriber unit to make the decision to receive the downloaded data or to not receive the downloaded data. Using this technique, it is not necessary that the MTSO keep track of each of the mobile subscribers in its geographic area that have received the updated SID list since that responsibility can be given to each of the mobile subscriber units. Other mobile subscriber units are not accessed until specifically selected since the message is addressed to just one mobile subscriber unit.

It is noted that a base station may send simultaneous instructions to a plurality of different mobile subscriber units, directing them to tune to separate (or the same) voice or traffic channels to receive the download of the most recent version of the preferred SID list, as well as other data considered appropriate. As a result, mobile subscriber units not designated will not receive the updated preferred SID list download. Because only those subscriber units designated are directed to tune to the designated voice channel, a general broadcast of the updated preferred SID list, as well as other relevant data, can be made on the assigned voice channel. This simplifies the downloading of the preferred SID list since a download can take place periodically and the system control mechanism does not have to keep track of the preferred SID list status of each of the mobile subscriber units in the geographic area of the communication system.

It is noted that one arrangement in a handset for receiving the preferred SID list download includes a modem such as

76 in FIG. 3) capable of receiving the downloads from an Intelligent Peripheral (IP). The IP can be an adjunct processor attached to a telephone switching office or MTSO 700 (depicted in FIG. 7). The IP will keep track of the latest versions of the SID list as well as other relevant data that may be downloaded with the SID list. It is noted that the IP can be part of the service provider center 705 or used in any part of an Advanced Intelligent Network (AIN) with which the service provider is associated. Consequently, if the mobile telephone switching office 700 is serviced by an SSP type switch, as part of a landline network associated with the mobile telephone system, the IP can be associated with that SSP switch. A disclosure of an AIN is found in U.S. Pat. No. 5,247,571 to Kay et al. (incorporated herein by reference). Further, the description of IPs and their use are found in U.S. patent application Ser. No. 08/248,980 (incorporated herein by reference).

Another method of updating the SID list includes the use of a PCS base station (similar to a cordless base station) as disclosed in U.S. Pat. No. 5,353,331 and U.S. patent application Ser. No. 08/321,675 (both incorporated herein by reference). The method of the present invention can be carried out by a download of the updated preferred SID list from the PCS home base station over cordless telephone frequencies to the subscriber unit handset. The PCS home base station would be provided with the updated preferred SID list via landline through the use of an AIN. When the subscriber unit handset registers with the PCS home base station, the registration process could include an inquiry to the AIN controlling of the landline system regarding the status of the latest preferred SID list. This inquiry could be part of the handshake/registration process so that once registration is confirmed, and the location of the subscriber unit handset known, SID list data could be downloaded through the AIN over CCIS lines, sent through the SS7 switch to the PCS home base station. From there, the relevant data could be transmitted via cordless telephone channels to the subscriber unit handset from the PCS base station. In the alternative, the handset may be plugged into the PCS base station for a direct download via hardware connections. In another version, infrared emitters could be used to transmit the relevant information between the PCS base station and the subscriber unit handset.

If the Personal Phone Number (PPN) of the patent application Ser. No. 08/321,675 is used, a request for a SID list download to the subscriber unit handset can be made with the request for cellular call forwarding. This request can be made by the cordless base station with which the subscriber unit handset is registered. The cordless base station can make the request via an AIN, or an IP associated with the SS7 switch feeding the cordless base station. The cordless base station can also control the subscriber unit handset to request the downloading of the most recent SID list on an appropriate voice channel. If the subscriber unit handset is to receive a download of the most recent version of the preferred SID list over cellular channels, it will be necessary that this be done before the cellular portion of the subscriber unit handset is deactivated by the base unit.

Another technique for downloading the updated SID list into the subscriber unit handset includes the use of a "smart card" to be inserted into an appropriate interface on the subscriber unit handset. Such a "smart card" would be provided by the service provider so that manual updating of the preferred SID list could be done by the subscriber. Such a "smart card" could also be used in conjunction with a home base station such as that used with the PCS or PPN systems. However, such manual downloading includes all

the problems and inconvenience previously mentioned, and so is generally not considered to be particularly beneficial to the subscriber except in those cases where maintenance or manual programming is considered desirable.

One such case exists for the FPN system when a subscriber is roaming from his or her home geographic area, and desires an arrangement whereby the roaming subscriber unit is considered to be in its home service provider area. In order to do this, a second home base station will have to be programmed to accept the roaming subscriber unit as a home subscriber unit. This can be accomplished by making an arrangement whereby the identification number of the foreign base station is treated like a SID and programmed into the roaming subscriber unit handset into the preferred SID list. When the roaming handset is within range of the foreign base station, it will be recognized as a home handset and treated accordingly, resulting in a lower billing rate for the roaming handset. As a result, a plurality of different subscriber unit handsets having access to a plurality of different foreign base stations. All that is needed is that the identification number necessary for a handshake routine with the foreign base station be treated as a preferred SID and programmed into the subscriber unit handset that is expected to roam.

The time and circumstances during which preferred SID list download may take place is not limited to that previously described. Rather, it is possible to download a SID list when incoming communication is being established with a subscriber unit handset. The downloading of the preferred SID list can take place between rings of an incoming call to a mobile subscriber unit, or before the subscriber at the mobile unit answers the incoming call. Downloading under such circumstances would establish beyond any doubt the identity of the mobile subscriber unit being provided with the updated preferred SID list. Extending this concept one step further, it is possible to perform the downloading of the updated preferred SID list in virtually any space found on the voice channels between voice communication traffic.

It is noted that an updated SID list downloaded into a subscriber unit handset after communication has begun may result in the recognition that communication has been established using a service provider that is now considered inappropriate on the basis of the updated preferred SID list. Consequently, it may be necessary to apply certain safeguards to prevent re-registration with a new service provider once communication has already begun. While such circumstances are considered rare, their occurrence may jeopardize high quality communication especially when hand-off is required. The programming that prevents re-registration during an ongoing telephone call is easily accomplished by one skilled in this art, and requires no further elaboration.

Likewise, techniques for bypassing the preferred SID list function are well known and easily carried out by those having skill in the art of programming cellular handsets. Thus, a subscriber may choose his or her own service provider regardless of the preferences stored in the SID list by carrying out a manual override using the keyboard on the subscriber unit handset or any other appropriate controls arranged to carry out such override functions.

One example of the other data that can be downloaded with the updated preferred SID list is a list of calling features that are available from service providers associated with each of the SIDs. One way of handling such an arrangement would be for the above-described selection using the preferred SID to be carried out and the registration with the associated service provider to be accomplished in order to activate any of the calling features listed along with selected

SID. The subscriber unit handset could be so programmed to indicate which of the calling features the subscriber is authorized to use by way of signals sent over a reverse control channel to the base station currently serving the subscriber unit handset.

A manual designation could be made by the subscriber operating the handset of which services he or she wishes to have in effect while registered with the new service provider. If the programming in the subscriber unit handset is considered insufficient to indicate proper authorization to use particular services, the MTSO of the current service provider could send a query to the home service provider to determine if such services are authorized to the subscriber. One method of carrying out such an inquiry could be over dedicated trunks connected the MTSOs of the different service providers. Another system could be the use of AIN connecting the MTSOs of the different service providers.

It will be readily seen by one of ordinary skill in the art that the present invention fulfills all of the objects set forth above. After reading the foregoing specification, one ordinary skill will be able to effect various changes, substitutes of equivalence and various other aspects of the invention as broadly disclosed herein.

Although a number of arrangements of the present invention have been mentioned by way of example, it is not intended that the invention be limited thereto. For example, the present invention can be adapted so that the preferred SID list is not necessarily placed in the subscriber unit or handset at the factory. Rather, it may be possible to program the preferred SID lists in a variety of ways. It is therefore intended that the protection granted hereon be limited only by the definition contained in the appended claims and equivalents thereof. Accordingly, this invention should be considered to include any and all configurations, modifications, variations, combinations or equivalent arrangements falling within the scope of the appended claims.

We claim:

1. A system for downloading data to radio telephone subscriber units, said system comprising:

- (a) control means for updating at least one system identifier list of preferred service providers for use by said radio telephone subscriber units and generating a version number corresponding to the at least one system identifier list;
- (b) means for broadcasting said version number to said radio telephone subscriber units over a radio telephone control frequency;
- (c) means in each of said radio telephone subscriber units for receiving said version number;
- (d) means in each of said radio telephone subscriber units for comparing said received version number to a version number previously stored in each of said radio telephone subscriber units; and
- (e) means in each of said radio telephone subscriber units for initiating and receiving a download of said at least one system identifier list from said broadcast means if said received version number and said previously stored version number fail to match.

2. The system of claim 1, wherein said means for broadcasting comprise at least one cell site base station of a cellular telephone system.

3. The system of claim 2, wherein said version number is broadcast as part of a cellular overhead message.

4. The system of claim 2, wherein said means for broadcasting comprise means for instructing each said radio telephone subscriber unit to tune to a predetermined frequency.

5. The system of claim 4, wherein said predetermined frequency is a cellular voice frequency.

6. The system of claim 4, wherein said predetermined frequency is a cellular telephone control frequency.

7. The system of claim 4, wherein said predetermined frequency is an AM broadcast frequency.

8. The system of claim 2, wherein said base station comprises means for downloading said at least one system identifier list to said radio telephone subscriber units.

9. The system of claim 1, wherein said control means comprise a Mobile Telephone Switching Office (MTSO).

10. A system for downloading data to radio telephone subscriber units, said system comprising:

(a) control means for updating a system identifier list of preferred service providers for use by said radio telephone subscriber units and for generating a version number corresponding to said system identifier list;

(b) means for broadcasting said version number over a radio telephone frequency;

(c) means for downloading said system identifier list to said radio telephone subscriber units within range of said means for downloading; and

(d) means for sequentially addressing each of said radio telephone subscriber units in range of said means for downloading system identifier list, and for initiating download of said system identifier list to said radio telephone subscriber units.

11. The system of claim 10, wherein each said radio telephone subscriber unit comprises means for storing said downloaded system identifier list and means for deleting previously stored system identifier lists in favor of newly downloaded system identifier lists.

12. The system of claim 10, wherein said means for addressing comprise means for correlating each of said radio telephone subscriber units within range of said means for downloading to a version of said system identifier list.

13. The system of claim 12, wherein said means for downloading is activated by said means for correlating to download a data list to a specific radio telephone subscriber unit identified as having an outdated version number.

14. The system of claim 10, wherein said system identifier list comprises a list of preferred system identification numbers.

15. The system of claim 14, wherein said means for downloading comprise at least one cellular telephone base station.

16. The system of claim 10, further comprising means for instructing said radio telephone subscriber units to tune to a predetermined frequency to receive a download of the system identifier list.

17. The system of claim 16, wherein said predetermined frequency is a cellular telephone voice frequency.

18. The system of claim 16, wherein said predetermined frequency is a cellular telephone control frequency.

19. The system of claim 16, wherein said predetermined frequency is an Amplitude Modulated (AM) broadcast frequency.

20. A method of downloading data to radio telephone subscriber units, comprising:

(a) generating a data list having a System Identification Number (SID) list of preferred service providers and a version number corresponding to said data list;

(b) broadcasting said version number to at least one of said radio telephone subscriber units over a radio telephone control frequency;

(c) comparing a received version number to a pre-stored version number in said at least one radio telephone

subscriber unit; and if the pre-stored version number does not correspond to said received version number,

(d) downloading said data list from a cellular base station into the at least one radio telephone subscriber unit in response to a download signal from said subscriber unit.

21. The method of claim 20, wherein said version number is broadcast as part of a cellular overhead message.

22. The method of claim 21, wherein step (d) comprises the sub-step of tuning to a cellular voice channel for a download of said data list.

23. The method of claim 20, wherein step (b) comprises a sub-step of addressing each radio telephone subscriber unit within range of a means for broadcasting said version number.

24. The method of claim 20, wherein step (d) comprises the sub-step of storing said data list downloaded to a radio telephone subscriber unit, and altering a pre-stored data list in said radio telephone subscriber unit.

25. A wireless telephone subscriber unit for use in a communication system having a plurality of frequencies divided into a plurality of available frequency bands, the wireless telephone subscriber unit comprising:

a first memory storing a list of system identifiers of preferred wireless telephone service providers and a corresponding version number;

a receiver for receiving a version number of an updated list of system identifiers over a wireless telephone central frequency;

a second memory storing the received version number; and

a processor comparing the received version number and the version number of the stored list, the processor initiating, in response to a comparison in which the version numbers fail to match, a download of said undated list from a mobile telephone switching office, and storing the received version number and the updated list downloaded to the wireless telephone subscriber unit into the first memory.

26. The unit of claim 25, wherein:

the stored list is prioritized based on the corresponding preferred wireless telephone service providers;

the second memory stores received system identifiers of available service providers, each of the available frequency bands having at least one corresponding system identifier;

the processor compares the received system identifiers for each said available frequency band to the stored list and selects one of the received system identifiers as having a highest priority in response to the stored list; and the receiver acquires a radio frequency carrier corresponding to the selected system identifier.

27. The unit of claim 25, wherein the stored list comprises a prioritized System Identification Numbers (SID) list of the preferred wireless telephone service providers.

28. A system having wireless communication with wireless telephone subscriber units, the system comprising:

a central controller generating a first system identifier list of preferred wireless telephone service providers and a first version number corresponding to the first system identifier list;

at least one wireless transmitter transmitting the first version number; and

at least one wireless telephone subscriber unit comprising:

(a) a wireless transceiver receiving said first version number over a wireless telephone control frequency;

23

- (b) a nonvolatile memory storing a second prioritized system identifier list and a corresponding second version number; and
- (c) a processor outputting a download request to said central controller in response to a comparison 5 between the first and second version numbers that fails to match, the processor storing in the nonvolatile memory the first system identifier list and the corresponding first version number upon reception by the subscriber unit from the central controller in response to said comparison. 10
29. The system of claim 28, wherein the first system identifier list is a prioritized list of the preferred wireless telephone service providers.
30. The system of claim 28, wherein the wireless transceiver receives the first system identifier list from the central controller and supplies the first system identifier list to the processor. 15
31. A system having wireless communication with wireless telephone subscriber units, the system comprising: 20
- a central controller generating a first system identifier list of preferred wireless telephone service providers and a first version number corresponding to the first system identifier list;
 - at least one wireless transmitter transmitting the first version number; and 25
 - at least one wireless telephone subscriber unit comprising:
 - (a) a wireless receiver receiving said first version number;
 - (b) a nonvolatile memory storing a second prioritized system identifier list and a corresponding second version number; and 30
 - (c) a processor outputting a download request in response to a comparison between the first and

24

- second version numbers, the processor storing in the nonvolatile memory the first system identifier list and the corresponding first version number upon reception by the subscriber unit from the central controller in response to said comparison, and wherein the first system identifier list is a prioritized list of the preferred wireless telephone service providers and wherein priority is based on contractual considerations.
32. A method of downloading a system identification number (SID) list of preferred service providers to a radio telephone subscriber unit, comprising:
- generating a preferred SID list and a version number corresponding to said preferred SID list at a mobile telephone switching office (MTSO);
 - broadcasting said version number to said subscriber unit over a radio telephone control frequency;
 - comparing the said version number to a pre-stored version number in said subscriber unit, and signaling the MTSO to download the preferred SID list when the compared version numbers do not match;
 - downloading said preferred SID list from said MTSO in response to a download signal from said subscriber unit; and
 - receiving said SID list in said subscriber unit.
33. The method of claim 32, wherein said version number is broadcast as part of a cellular overhead message.
34. The method of claim 32, wherein said SID list is downloaded over a cellular voice channel.

* * * * *



US005666650A

United States Patent [19]
Turcotte et al.

[11] **Patent Number:** **5,666,650**
 [45] **Date of Patent:** **Sep. 9, 1997**

[54] **SPLIT NEIGHBOR LISTS FOR MULTIPLE
 HYPERBAND CAPABLE CELLULAR
 COMMUNICATIONS SYSTEMS**

Fifth Nordic Seminar on Digital Mobile Radio Communi-
 cations; *DMR V Proceedings*; Helsinki Finland; Ph.Dup-
 lessis, P.Simmons; pp. 1-3; Dec. 1992.

[75] **Inventors:** **Eric Turcotte, Verdun; Richard
 Brunner, Montreal, both of Canada**

Primary Examiner—Reinhard J. Eisenzopf
Assistant Examiner—Darnell R. Armstrong
Attorney, Agent, or Firm—Jenkins & Gilchrist P. C.

[73] **Assignee:** **Telefonaktiebolaget LM Ericsson,
 Stockholm, Sweden**

[21] **Appl. No.:** **426,675**

[57] **ABSTRACT**

[22] **Filed:** **Apr. 19, 1995**

[51] **Int. Cl.** **H04Q 7/00**

[52] **U.S. Cl.** **370/329; 455/509**

[58] **Field of Search** **455/33.1, 34.1,
 455/54.1, 56.1, 62, 63, 67.1, 67.3, 33.2;
 379/39, 60**

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,916,728	4/1990	Blair	379/59
5,293,641	3/1994	Kallin et al.	455/33.1
5,499,386	3/1996	Karlsson	455/33.2
5,504,939	4/1996	Mayrand et al.	455/34.1
5,535,259	7/1996	Dent	379/59

OTHER PUBLICATIONS

IEEE Journal on Selected Areas in Communications, vol.
 13, No.2, Feb. 1995; The GSM Procedures in an Integrated
 Cellular/Satellite System; P.Iannucci; pp. 421-430.

A split neighbor list for a multiple hyperband capable
 cellular communications system. The neighbor list includes
 a first data set targeted to Cellular hyperband only capable
 mobile stations identifying available Cellular hyperband
 channels. The split neighbor list further includes a second
 data set targeted to multiple hyperband capable mobile
 stations identifying available Cellular and PCS hyperband
 channels. In processing the first and second data sets of the
 split neighbor list, the multiple hyperband capable mobile
 stations replace the cellular channels identified in the first
 data set with cellular channels from the second data set prior
 to server selection or hand-off determination processing.
 Alternatively, channel information is extracted from the first
 data set to complete the second data set.

25 Claims, 2 Drawing Sheets

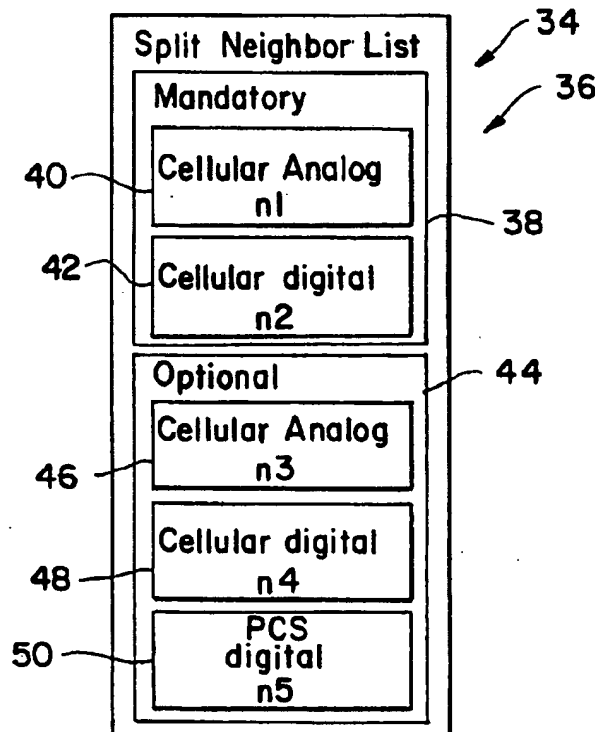


FIG. 1
PRIOR ART

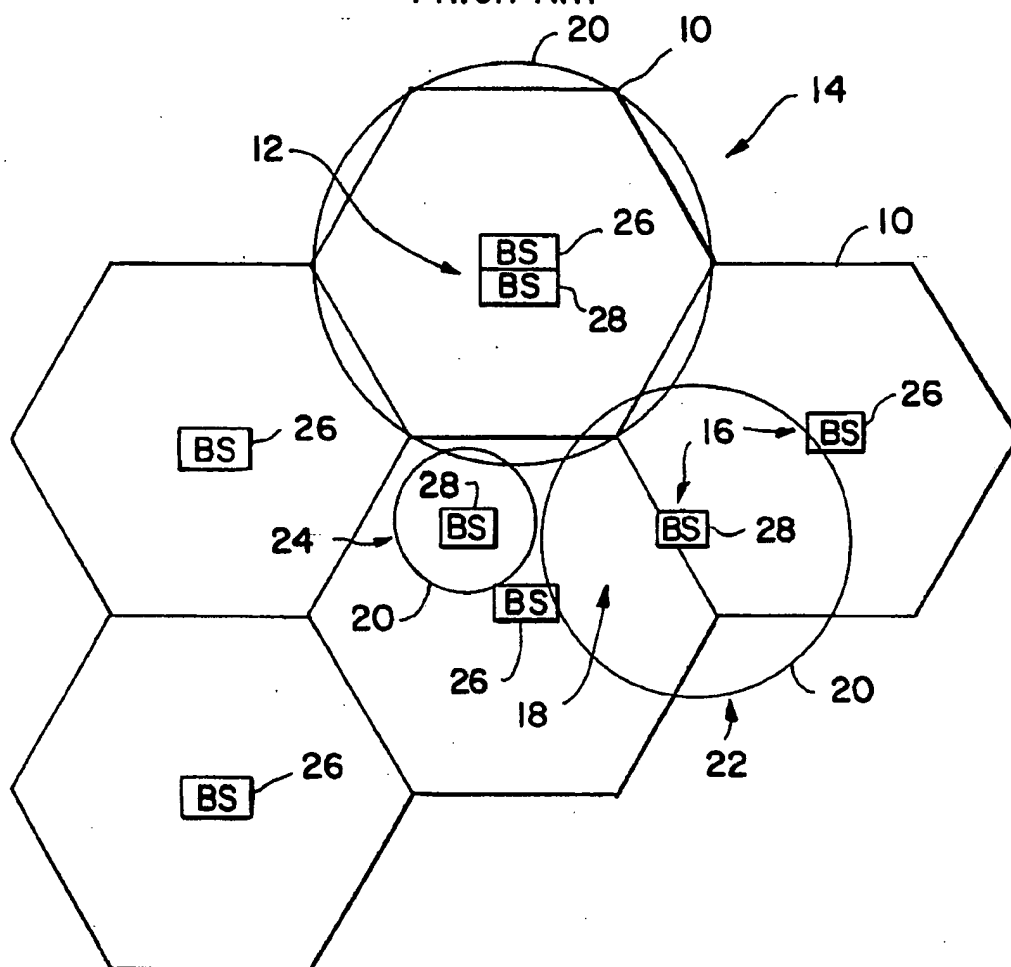


FIG. 2
PRIOR ART

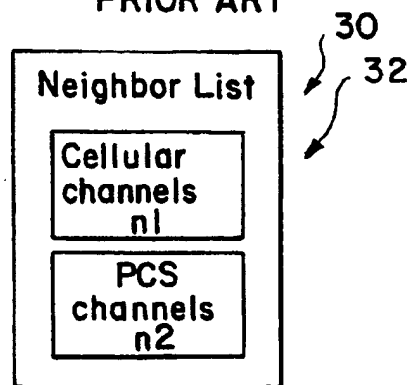


FIG. 3

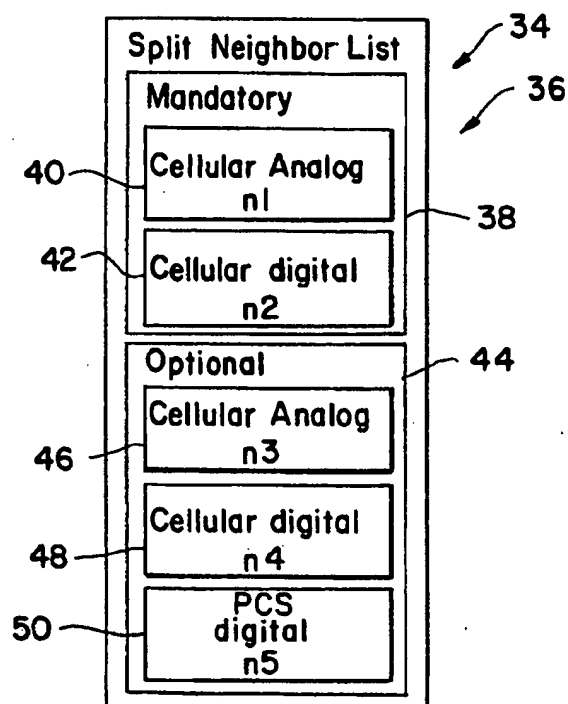
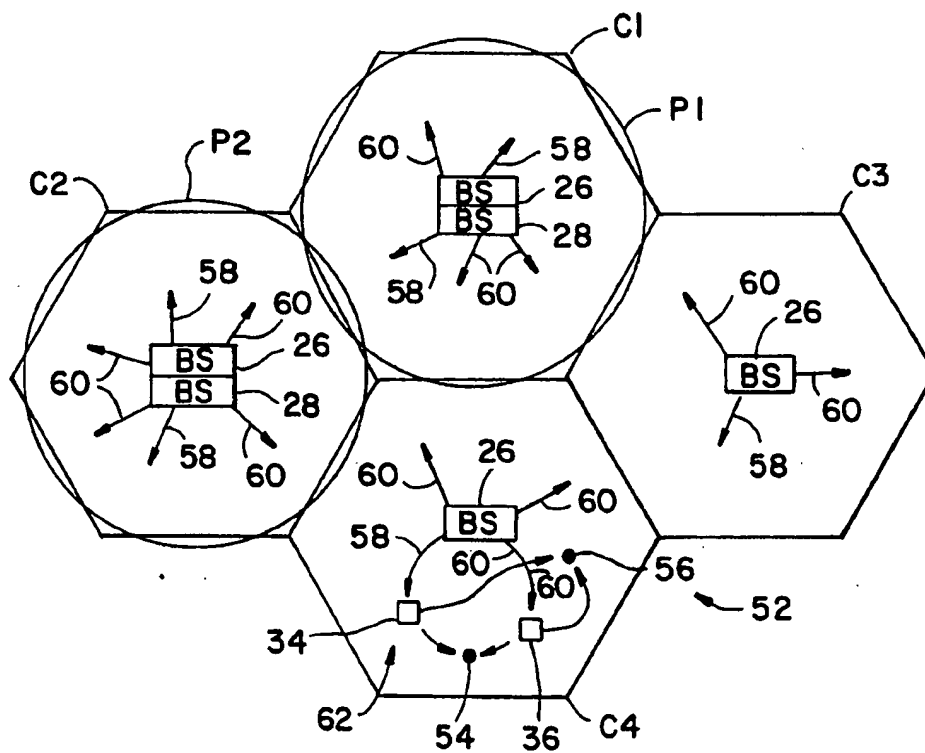


FIG. 4



SPLIT NEIGHBOR LISTS FOR MULTIPLE HYPERBAND CAPABLE CELLULAR COMMUNICATIONS SYSTEMS

BACKGROUND OF THE INVENTION

1. Technical Field of the Invention

The present invention relates to cellular communications systems and, in particular, to such systems implementing multiple hyperband communications capabilities.

2. Description of Related Art

North American cellular communications have historically been implemented solely in the 800 MHZ Cellular hyperband. This Cellular hyperband is assigned two telephone frequency bands (commonly referred to as the A frequency band and the B frequency band) for carrying communications. The A and B frequency bands include the paging, control and other associated signaling channels necessary for setting up and maintaining cellular telephone calls, as well as the voice channels that are provided for carrying subscriber telephone communications.

Each frequency band within the Cellular hyperband is typically assigned to only one service company and is provided in the service area by that service company. For example, the A frequency band is usually reserved for use by non-wire line communications service companies, and the B frequency band is usually reserved for use by wire line communications service companies. In some instances, the particular communications frequency band (A or B) within the Cellular hyperband assigned to one service company for a given cell or service area may be assigned to a different service company in another cell or service area. Furthermore, in some cases the same service company will provide cellular communications service across both frequency bands. Alternatively, the individual channels within one frequency band may be assigned to different companies. The assignment of channels, frequency bands and hyperbands to service providers is dependent upon many factors including, for example, the size of the service area, the number of potential subscribers and the number of contracting providers.

The most recent evolution in cellular communications services involves the adoption of hyperbands other than the Cellular hyperband for handling mobile station communications. In accordance with the EIA/TIA Interim Standard IS-136 described in TIA project number PN3011 (the "IS-136 specification"), and specification PN3388-1 version Sep. 9, 1994, four different hyperbands have now been specified for use in handling mobile communications. These hyperbands comprise the Cellular hyperband previously in use and described briefly above, the Personal Communication Services (PCS) hyperband which has been established in the 1900 MHZ frequency range, and two other hyperbands that are currently reserved for future use but are not yet fully specified in terms of their operating characteristics.

Whereas the Cellular hyperband includes two frequency bands (A and B), the PCS hyperband in the United States of America is specified to include six different frequency bands (A, B, C, D, E and F). Thus, in accordance with the current IS-136 and PN3388 specifications, eight frequency bands (including multiple channels therein) are now available in any given service area to facilitate cellular communications services. With the existence of the new PCS hyperband, different types of subscriptions and/or services like speech quality, voice privacy, and encryption may exist from one hyperband to another, or from one frequency band in the Cellular hyperband to another frequency band in the PCS hyperband.

Reference is now made to FIG. 1 wherein there is shown a cell diagram illustrating an exemplary cell configuration for implementing multiple hyperband cellular communications services over an arbitrary geographic area (hereinafter "the service area") in accordance with the current IS-136 and PN3388 specifications utilizing both the Cellular and PCS hyperbands. The service area is divided into a plurality of cells 10 and 20. The cells 10 are represented by hexagrams and comprise communications cells wherein as many as two separate frequency bands (A and B) of radio frequency cellular communications are provided via multiple channels in the Cellular hyperband. The cells 20, are represented by circles and comprise communications cells wherein as many as six separate frequency bands (A through F) of radio frequency cellular communications are provided to mobile stations via multiple channels in the PCS hyperband.

In some instances, the Cellular hyperband cells 10 and the PCS hyperband cells 20 will be co-located, as generally shown at 12, and further may have comparable communications coverage areas, as generally shown at 14. Such cell characteristics, however, are not requirements for operation of a multiple hyperband communications system in accordance with the IS-136 and PN3388 specifications. Thus, different cell center locations and instances of overlapping cell coverage areas between the hyperbands will be a common occurrence, as generally shown at 16 and 18, respectively. Furthermore, it will often be the case that the combined communications coverage areas provided by all or part of two or more Cellular hyperband cells 10 will be contained within the coverage area of a single PCS hyperband cell 20, as generally shown at 22. Similarly, it is possible that the combined communications coverage areas provided by all or part of a PCS hyperband cell 20 will be contained within the coverage area of a single Cellular hyperband cell 10, as generally shown at 24.

Each of the Cellular hyperband cells 10 includes at least one base station 26 configured to facilitate communications over certain channels in at least one of the two available Cellular hyperband frequency bands. It is possible, and in fact may be preferred, for each of the cellular base stations 26 to possess the capability of communicating over both the A and B frequency bands of the Cellular hyperband. Similarly, each of the PCS hyperband cells 20 includes at least one PCS base station 28 configured to facilitate communications over certain channels in at least one of the six available PCS hyperband frequency bands. As with the cellular base stations 26, it is possible, and in fact may be preferred, for each of the PCS base stations 28 to possess the capability of communicating over more than one, and perhaps all six, of the frequency bands of the PCS hyperband. Although not shown in the figure for reasons of simplifying the illustration, in instances where a base station 26 or 28 does not provide coverage for all of the available hyperbands and/or the frequency bands therein, more than one base station will be needed in each cell. Furthermore, more than one base station may be needed per cell if there is a division of communications responsibility between service providers on a per channel basis.

The base stations 26 and 28 are illustrated as being positionally located at or near the center of each of the cells 10 and 20, respectively. However, depending on geography and other known factors, the base stations 26 and 28 may instead be located at or near the periphery of, or otherwise away from the centers of, each of the cells 10 and 20. In such instances, the base stations 26 and 28 may broadcast and communicate with mobile stations located within the cells

10 and 20 using directional rather than omni-directional antennas. Each one of the base stations 26 and 28 includes a transmitter, a receiver, and a base station controller connected to the antenna in a manner and with a configuration well known in the art.

Each one of frequency bands specified for the Cellular and PCS hyperbands is allocated a plurality of voice or speech channels and at least one access or control channel. The voice or speech channels carry subscriber telephonic communications. The control channel is used to control or supervise the operation of mobile stations by means of information transmitted to and received from the mobile stations. Such information may include incoming call signals, outgoing call signals, page signals, page response signals, location registration signals, voice channel assignments, maintenance instructions, and cell selection or reselection instructions as a mobile station travels out of the radio coverage of one cell and into the radio coverage of another cell. The control or voice channels may operate either in an analog or digital mode or a combination thereof.

Many mobile stations having Cellular hyperband only communications capabilities were purchased prior to the adoption of the new multiple hyperband IS-136 and PN3388 specifications and are currently in use. These Cellular hyperband only capable mobile stations do not possess the functionality to access and communicate over, and thus fully take advantage of, the PCS hyperband. Accordingly, multiple hyperband capable mobile stations possessing communications capabilities in both the Cellular and PCS hyperbands have been developed and are now being placed into service in order for subscribers and providers to take full advantage of the hyperbands (and frequency bands therein) made available by the new IS-136 and PN3388 specifications.

Reference is now made to FIG. 2. In accordance with the new IS-136 specification, each mobile station functioning in idle operating mode receives from the cellular communications system a neighbor list 30 identifying the channels available to the mobile station for server selection. This neighbor list is transmitted to each mobile station over the control channel. In order to account for the availability in the service area of the PCS hyperband and the frequency bands therein, the server selection neighbor list 30 transmitted to each mobile station must include an identification of the channels available to the mobile station in both the Cellular (n1) and PCS (n2) hyperbands.

Unfortunately, the IS-136 specification allows for a maximum of twenty-four channels across both available hyperbands ($n1+n2 \leq 24$) to be included in the server selection neighbor list 30 processed by each mobile station. The n2 portion of the server selection neighbor list 30 identifying available PCS hyperband channels is, however, of no use to Cellular hyperband only capable mobile stations which cannot communicate over the PCS hyperband channels. The inclusion of PCS hyperband channels in the server selection neighbor list 30 further serves to displace from the list certain (n2 in number) available Cellular hyperband channels that otherwise would have been provided for selection to the Cellular hyperband only mobile stations.

A similar problem under the IS-136 specification is presented when the mobile stations are functioning in an on call operating mode. In this case, the mobile station receives from the cellular communications system a MAHO neighbor list 32 identifying the channels the system wants the mobile station to scan for, measure on and report on periodically for purposes of making hand-off determinations. This MAHO neighbor list 32 is transmitted to each mobile station over the

voice channel, and is determined from the hyperband capabilities of the mobile station and the channels identified in the neighbor list 30. A Cellular hyperband only capable mobile station will receive a MAHO neighbor list 32 which includes an identification of channels from the neighbor list 30 only in the Cellular hyperband. A multiple hyperband capable mobile station, on the other hand, will receive a MAHO neighbor list 32 identifying channels from the neighbor list 30 in both the Cellular and PCS hyperbands. It should be understood that the previous description specific to IS-136 is also applicable to its counterpart PN3388 specification.

Accordingly, there is a need for a cellular communications system having multiple hyperband communications capabilities that will make more efficient use of the limited number of entries allowed by the IS-136 and PN3388 specifications in both the server selection and MAHO neighbor lists. Such a system will provide relevant, useful and sufficient information not only to those mobile stations that are capable of operating across multiple hyperbands, but also to the large number of Cellular hyperband only capable mobile stations that are currently in use by cellular subscribers.

SUMMARY OF THE INVENTION

To address the foregoing problems associated with the transmission of server selection and MAHO neighbor lists to mobile stations operating in an IS-136, PN3388 specified multiple hyperband capable cellular communications system, the cellular communications system of the present invention transmits split server selection and MAHO neighbor lists to mobile stations.

The split neighbor list of the present invention includes a first data set identifying as many as twenty-four different Cellular hyperband candidate channels that may be selected for communications. The transmission further includes a second data set identifying as many as twenty-four different Cellular and PCS hyperband candidate channels that may be selected for communications. The first data set of the split neighbor list is targeted to Cellular hyperband only capable mobile stations, and the second data set is targeted to multiple hyperband capable mobile stations.

A cellular only capable hyperband mobile station will receive and process only the Cellular hyperband channels identified in the first data set, and ignore the Cellular and PCS hyperband channels identified in the second data set. Thus, in conformance with the IS-136 specification, the Cellular hyperband only capable mobile station will receive and process no more than the limit of twenty-four channels.

A multiple hyperband capable mobile station will, like the Cellular only hyperband mobile station, receive the Cellular hyperband channels identified in the first data set. However, the mobile station will substitute the Cellular hyperband channels identified in the second data set, if present, for those previously identified and received in the first data set to reduce the number of identified Cellular hyperband channels. Such a substitution further provides sufficient space for the receipt of PCS hyperband channels that are also identified in the second data set. Alternatively, Cellular hyperband channels identified in the first data set are selectively extracted to be included with the PCS hyperband channels identified in the second data set. Again, in conformance with the IS-136, PN3388 specification, the multiple hyperband capable mobile station will, after Cellular hyperband channel substitution or extraction, receive and process a total of no more than the limit of twenty-four Cellular and PCS hyperband channels.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the split neighbor lists for the multiple hyperband cellular communications system of the present invention may be had by reference to the following Detailed Description when taken in conjunction with the accompanying Drawings wherein:

FIG. 1 is a cell diagram illustrating an exemplary cell configuration for implementing multiple hyperband cellular communications service in accordance with the current IS-136 and PN3388 specifications using both the Cellular and PCS hyperbands;

FIG. 2 is a block diagram illustrating the format of the server selection and MAHO neighbor lists in accordance with the IS-136 specification;

FIG. 3 is a block diagram illustrating the format of the split server selection and MAHO neighbor lists utilized in the multiple hyperband cellular communications system of the present invention; and

FIG. 4 is a cell diagram illustrating a multiple hyperband capable cellular communications system implementing the split neighbor list transmissions of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

Reference is now made to FIG. 3 wherein there is shown a block diagram of the split server selection and MAHO neighbor lists 34 and 36, respectively, of the present invention which are designed to replace the currently used IS-136 specification neighbor lists shown in FIG. 2.

Each of the neighbor lists 34 and 36 includes a first data set 38 identifying as many as twenty-four different Cellular hyperband channels available to either a Cellular hyperband only mobile station or a multiple hyperband mobile station. These specified channels in the first data set 38 are identified in a first data field 40 including a listing of n_1 available Cellular hyperband analog control channels, and a second data field 42 including a listing of n_2 available Cellular hyperband digital control channels (DCCH) (wherein $n_1+n_2 \leq 24$).

The neighbor lists 34 and 36 further optionally include a second data set 44 identifying as many as twenty-four different Cellular and PCS hyperband channels available to a multiple hyperband capable mobile station. These specified channels in the second data set 44 are identified in a first data field 46 including a listing of n_3 available Cellular hyperband analog control channels, a second data field 48 including a listing of n_4 available Cellular hyperband digital control channels (DCCH), and a third data field 50 including a listing of n_5 available PCS hyperband digital control channels (DCCH) (wherein: $n_3+n_4+n_5 \leq 24$).

The split server selection neighbor list 34 is transmitted over the control channel to multiple mobile stations functioning in the idle operating mode in a given cell. This list 34 identifies the channels available to the mobile station for server selection. The split MAHO neighbor list 36, on the other hand, is transmitted uniquely to individual mobile stations over the voice channel when the mobile station is functioning in the on call operating mode. This list 36 comprises, or is a subset of, the server selection neighbor list 34 that would be received by the mobile station if it were currently functioning in the idle operating mode. The MAHO list 36 accordingly identifies the channels that the communications system wants the mobile station to scan for, measure on, and report on periodically for purposes of facilitating system made hand-off determinations.

Reference is now made to FIG. 4 wherein there is shown a cell diagram illustrating a multiple hyperband capable

cellular communications system 52 implementing the server selection and MAHO split neighbor lists 34 and 36, respectively, of the present invention. The communications system comprises a number of Cellular hyperband cells C1-C4 and a number of PCS hyperband cells P1-P2. Within cell C4 of the system, there are currently located a Cellular hyperband only capable mobile station 54, and a multiple hyperband (Cellular and PCS) capable mobile station 56.

For each of the cells C1-C4 and P1-P2, the system 52 through base stations 26 and 28 transmits to each mobile station located therein a list of its cell "neighbors," and in particular the communications channels available therein, for the purpose of server selection. The server selection neighbor list 34 is transmitted to the mobile stations over the control channel 58 for the system 52. Conversely, while engaged in a subscriber communication, each mobile station will receive a transmission from the system a list of neighboring cells (and channels therein) for purposes of hand-off. This MAHO neighbor list 36 is transmitted to the mobile stations over the voice channel 60 currently in use by the mobile station for carrying subscriber voice communications (i.e., a telephone call). The MAHO neighbor list 36 comprises, or is a subset of, the server selection neighbor list 34 that would be received by the mobile stations 54 and 56 if they were functioning instead in the idle operating mode.

The mobile stations 54 and 56 are shown currently located in cell C4, and are assumed for the moment to be functioning in the idle operating mode. In accordance with the format of FIG. 3, and as generally indicated at 62, the split server selection neighbor list 34 transmitted by the system over the control channel 58 includes a mandatory first data set 38 identifying available Cellular hyperband channels (via fields 40 and 42) in neighboring Cellular hyperband cells C1, C2 and C3. The transmitted neighbor list 34 further includes an optional second data set 44 identifying the available Cellular and PCS hyperband channels (via fields 46, 48 and 50) in neighboring Cellular and PCS hyperband cells C1, C2, C3, P1 and P2. In order to comply with the limitations of the IS-136 specification, neither the first nor the second data set will individually include an identification of more than twenty-four channels, although it will be understood that the total number of channels identified in the neighbor list 34 across both data sets may exceed twenty-four in number.

The Cellular hyperband only capable mobile station 54 will receive the entire neighbor list 34 transmission, but will only use the information in the fields 40 and 42 in the first data set 38 concerning the available analog and digital Cellular hyperband channels in making its server selection determination. The Cellular and PCS hyperband information identified in the second data set will be ignored. Thus, the mobile station 54 will process no more than twenty-four potential neighbors in making its server selection determination, because no more than twenty-four channels will be included in the first data set 38 of the neighbor list 34.

The multiple hyperband capable mobile station 56, like the cellular only mobile station 54, will receive the entire neighbor list 34 transmission. The entire neighbor list 34 will not, however, be used by the mobile station 56 in making its server selection determination. The information in the first and second fields 40 and 42 of the first data set 38 concerning up to twenty-four available analog and digital Cellular hyperband channels will be used for server selection only if no other substitute information is provided by the system 52.

If the transmitted neighbor list 34 further includes a second data set 44, and if the second data set includes

channel information in either or both the first and second fields 46 and 48, respectively, relating to available Cellular hyperband channels, this included information from the second data set will replace (through a substitution) the corresponding Cellular hyperband channel information previously received and included in the first data set 38. For example, the (n3) Cellular hyperband channel information in the second data set 44, first field 46, if included in the transmission, will replace the (n1) corresponding information previously received in the first data set 38, first field 40 of the transmission (thus, $n2+n3+n5 \leq 24$). The mobile station 56 will further receive in the second data set 44, third field 50, of the neighbor list 34 transmission an identification of the (n5) available PCS hyperband channels. It is from the substituted Cellular hyperband channel information and the received PCS hyperband channel information that the multiple hyperband mobile station 56 will make its server selection determination. The substitution of the Cellular channels identified in the second data set 44 for those identified in the first data set 38 guarantees that the mobile station 56 will receive and process in accordance with the IS-136 specification no more than twenty-four potential neighbors in making its server selection determination (thus, $n1+n2+n5 \leq 24$; $n1+n4+n5 \leq 24$).

As an alternative to substitution as described above, either or both of the first and second fields 46 and 48 of the second data set 44 may include a "null" indication and thus specify no channels. In such a case, the multiple hyperband mobile station 56 will identify PCS hyperband channels from the third field 50 of the second data 44, and will fill in the remainder of the available slots in the neighbor list (up to twenty-four entries) by selecting Cellular hyperband channels identified in fields 40 and 42 of the first data set 38. This "extraction" of cellular channels from the first data set 38 guarantees that the mobile station receives and processes sufficient channel information without violating the IS-136/PN3388 specifications.

Assuming now that the mobile stations 54 and 56 are instead functioning in the on call mode of operation, the system 52 will transmit a similar split neighbor list 36 with the format shown in FIG. 3 in the form of a MAHO list. As is well known to those skilled in the art, the MAHO neighbor list 36 identifies those channels that the system 52 wants the mobile station to scan for, make signal strength measurements on, and report on periodically to facilitate the making of a hand-off determination by the system. This MAHO list 36, unlike the server selection list 34, is unique to each mobile station and is transmitted by the system 52 over the voice channel 60 that is also carrying the telephonic voice communication of the subscriber.

The MAHO neighbor list 36 comprises, or is a subset of, the server selection neighbor list 34 that would have been received by the mobile stations over the control channel had the mobile stations been functioning in the idle operating mode. Again, as with the server selection neighbor list 34 of the present invention described above, the split MAHO neighbor list 36 will include a mandatory first data set 38 identifying Cellular hyperband neighbors and an optional second data set 44 identifying both Cellular and PCS hyperband neighbors. A Cellular hyperband only capable mobile station 54 will receive and process only those neighbors identified in the first data set 38 in making its hand-off determination. The information in the second data set 44 will be ignored. The multiple hyperband capable mobile station 56, on the other hand, will substitute the Cellular hyperband information (n3 and n4) in the second data set 44, if present, for the corresponding information (n1 and n2) previously

sent in the first data set 38. Alternatively, in the event of a null transmission in one of the fields 46 or 48 of the second data set 44, channel information in the Cellular hyperband will be extracted from the first data set 38 and added to the PCS information. In no event, however, will the mobile stations 54 and 56 process more than twenty-four potential channels across the various hyperbands.

It is often the case that the provider of cellular service, as well as the subscriber himself, will desire to engage in cellular communications over only certain ones of the available channels in each of the provided hyperbands. For example, the provider of service may desire for the mobile station to engage in communications over only those channels to which the provider has been assigned control even though the mobile is capable of communicating over many other channels provided by others. Such restriction is desired because in many instances it is only from these owned channels that the provider can derive revenue from subscriber usage. Similarly, the subscriber himself may desire to only use certain ones of the many channels in the various hyperbands because access to channels provided by others may result in the assessing of a surcharge or other increased cost for the call.

With the split server selection and MAHO neighbor list of the present invention, not only does each type of mobile station receive up to twenty-four identified channels thus fully utilizing and satisfying the IS-136 specification, but also the system 52 has the capability of selectively transmitting to the mobile station only those channels that the service provider or subscriber desires. The provider may then in effect institute a preference through the transmission of the neighbor lists for the mobile station to utilize the provider's own channels. The neighbor list broadcast by the system will accordingly not include those channels of other providers, even though the mobile station is capable of scanning for, measuring on, and using these channels. The subscriber also benefits from this selective inclusion of channels in the neighbor list because the mobile station will operate to select only those channels for which no surcharge or other fee will be incurred during usage.

Although the split neighbor list of the present invention has been described with respect to server selection and hand-off for only the Cellular and PCS hyperbands, it will be understood that a split neighbor list in accordance with the present invention may be defined and utilized, in conformance with the IS-136 specification or otherwise, for any multiple hyperband cellular communications network or other communications system as are or become known to those skilled in the art. Thus, although a preferred embodiment of the present invention has been disclosed herein and illustrated in the accompanying Drawings, it is understood that the invention is not limited to the embodiment disclosed, but rather is capable of numerous rearrangements, modifications and substitutions without departing from the spirit of the invention as set forth and defined by the following claims.

What is claimed is:

1. A cellular communications system providing communications to mobile stations over a plurality of hyperbands, each hyperband including a plurality of available communications channels, the system comprising:

means for transmitting to mobile stations a neighbor list identifying available channels for communication, the neighbor list being split, to include:

a first data set identifying available first channels for mobile station communication in a first one of the

plurality of hyperbands, the number of first channels not exceeding a predetermined maximum number of channels; and

a second data set identifying available second channels for mobile station communication in the first one of the plurality of hyperbands and available third channels in a second one of the plurality of hyperbands, the sum of the number of second and third channels not exceeding the predetermined maximum number of channels.

2. The system of claim 1 wherein the available second channels identified in the second data set comprise substitute channels for replacing the first channels identified in the first data set.

3. The system as in claim 1 wherein certain ones of the available first channels are extracted from the first data set for replacing second channels missing from the first data set.

4. The system as in claim 1 wherein the neighbor list comprises a server selection neighbor list.

5. The system as in claim 1 wherein the neighbor list comprises a MAHO neighbor list.

6. The system as in claim 1 wherein the mobile stations comprise first hyperband only capable mobile stations and multiple hyperband capable mobile stations, the information in the first data set of the neighbor list being split, being targeted to first hyperband only mobile stations, and the information in the second data set of the neighbor list being split, being targeted to multiple hyperband capable mobile stations.

7. The system as in claim 6 wherein the available second channels identified in the second data set are substituted by multiple hyperband capable mobile stations for the first channels identified in the first data set in order to present for neighbor list consideration no more than the predetermined maximum number of channels.

8. The system as in claim 6 wherein certain ones of the first channels are extracted from the first data set by multiple hyperband capable mobile stations to replace second channels of the second data set if no second channels are identified.

9. A method for transmitting channel information to mobile stations operating in a cellular communications system including a plurality of hyperbands, each hyperband having a plurality of available communications channels, the method comprising the steps of:

transmitting a neighbor list to mobile stations identifying available channels for communication, the neighbor list being split, to include:

a first data set identifying available first channels for mobile station communication in a first one of the plurality of hyperbands, the number of first channels not exceeding a predetermined maximum number of channels; and

a second data set identifying available second channels for mobile station communication in the first one of the plurality of hyperbands and available third channels in a second one of the plurality of hyperbands, the sum of the second and third channels not exceeding the predetermined maximum number of channels;

receiving, by first hyperband only capable ones of the mobile stations, said transmitted neighbor list being split;

receiving, by multiple hyperband capable ones of the mobile stations, said transmitted split neighbor list;

processing said received neighbor list being split, by the first hyperband only capable mobile stations to choose

for communications among first channels identified in the first data set; and

processing said received neighbor list being split, by the multiple hyperband capable mobile stations to choose for communications among the second and third channels identified in the second data set.

10. The method of claim 9 wherein the step of processing of the received neighbor list being split, by the multiple hyperband capable mobile stations further includes the step of substituting the second channels identified in the second data set for the first channels identified in the first data set.

11. The method as in claim 9 wherein the step of processing of the received neighbor list being split, by the multiple hyperband capable mobile stations further includes the steps of:

extracting certain ones of the first channels identified in the first data set; and

substituting the extracted first channels for the second channels of the second data set if no second channel are identified.

12. A split neighbor list for use multiple hyperband capable cellular communications system, comprising:

a first data set identifying available channels for mobile station communications in a first one of a plurality of system supported communications hyperbands, said first data set targeted to mobile stations capable of operating only in the first hyperband; and

a second data set identifying available channels for mobile station communications in both the first and a second one of a plurality of system supported communications hyperbands, said second data set targeted to mobile stations capable of operating in both the first and second hyperbands.

13. The split neighbor list of claim 12 wherein the total number of available channels in the first data set does not exceed a predetermined maximum.

14. The split neighbor list as in claim 13 wherein the total number of available channels in the second data set does not exceed the predetermined maximum.

15. The split neighbor list as in claim 12 wherein the channels of the first data set include analog and digital channels available in the first hyperband.

16. The split neighbor list as in claim 12 wherein the channels of the second data set include analog and digital channels available across the first and second hyperbands.

17. The split neighbor list as in claim 12 wherein the channels of the second data set for the first hyperband are substituted for the channels of the first data set of the first hyperband by mobile stations capable of operating in both the first and second hyperbands.

18. The split neighbor list as in claim 12 wherein certain ones of the channels of the first data set for the first hyperband are extracted to replace channels of the second data set for the first hyperbands by mobile stations capable of operating in both the first and second hyperbands if no channels of the first hyperband are identified.

19. A cellular communications system, comprising:

a plurality of first mobile stations capable of operation in only a first one of a plurality of available hyperbands, said first hyperband including a plurality of communications channels;

a plurality of second mobile stations capable of operation in both the first and a second one of the plurality of available hyperbands, said second hyperband including a plurality of communications channels; and

means for transmitting a neighbor list to mobile stations identifying available channels across the hyperbands

11

for mobile station communication, the neighbor list being split, to include:

a first part identifying available channels for first mobile station communication in the first hyperband; and

a second part identifying available channels for second mobile station communication in both the first and second hyperbands.

20. The system as in claim 19 wherein the neighbor list comprises a server selection neighbor list.

21. The system as in claim 19 wherein the neighbor list comprises a MAHO neighbor list.

22. The system as in claim 19 wherein the first mobile stations select a channel in the first hyperband from those identified in the first part of the neighbor list being split.

12

23. The system as in claim 19 wherein the second mobile stations select a channel in either the first or second hyperbands from those identified in the second part of the neighbor list being split.

5 24. The system as in claim 19 wherein the second mobile stations substitute channels of the first hyperband identified in the second part of the neighbor list being split, for those channels of the first hyperband identified in the first part of the neighbor list being split.

10 25. The system as in claim 19 wherein the second mobile stations extract channels of the first hyperband identified in the first part of the neighbor list being split, to replace channels of the first hyperband if no such channels are identified in the second part of the neighbor list being split.

* * * * *



US005809416A

United States Patent [19][11] **Patent Number:** **5,809,416****Pinault et al.**[45] **Date of Patent:** **Sep. 15, 1998**

[54] **DEVICE FOR SEEKING CONNECTION OF A
TERMINAL TO A NETWORK OF A MOBILE
RADIO SYSTEM COMPRISING A
PLURALITY OF NETWORKS**

[75] **Inventors:** **Francis Pinault; Christophe Jouin,**
both of Bois-Colombes, France

[73] **Assignee:** **Alcatel Radiotelephone, Paris, France**

4,905,301 2/1990 Kropp et al. 455/334
4,916,728 4/1990 Blair .
5,101,500 3/1992 Marui 455/33.1
5,117,502 5/1992 Onoda et al. 379/60
5,157,661 10/1992 Kanai et al. 379/63
5,159,625 10/1992 Zicker .
5,203,015 4/1993 George 455/186.1
5,222,248 6/1993 McDonald et al. 455/54.2
5,276,905 1/1994 Hurst et al. 455/54.2

[21] **Appl. No.:** **767,297**

FOREIGN PATENT DOCUMENTS

[22] **Filed:** **Dec. 16, 1996**

0382309 8/1990 European Pat. Off. .

Related U.S. Application Data

[63] Continuation of Ser. No. 166,954, Dec. 15, 1993, abandoned.

[30] Foreign Application Priority Data

Dec. 16, 1992 [FR] France 92 15203

[51] **Int. Cl.⁶** **H04Q 7/00**

[52] **U.S. Cl.** **455/422; 455/432; 455/455;
455/552**

[58] **Field of Search** 455/33.1, 33.2,
455/34.2, 53.1, 54.1, 54.2, 56.1, 62, 63,
33.4, 422, 432, 436, 437, 438, 439, 443,
444, 450, 455, 456, 517, 516, 507, 524,
551-552; 379/58, 59, 60, 63

[56] References Cited**U.S. PATENT DOCUMENTS**

4,903,320 2/1990 Hanawa 455/34.2

Primary Examiner—Reinhard J. Eisenzopf

Assistant Examiner—Doris To

Attorney, Agent, or Firm—Sughrue, Mion, Zinn, Macpeak
& Seas, PLLC

[57]

ABSTRACT

A connection seeking device in a terminal of a mobile radio system seeks connection of the terminal to one network of a system which includes a plurality of networks. The system extends over a plurality of geographical entities each having at least one network. The terminal is affiliated to a home network belonging to a geographical entity of origin. The device seeks the connection to the home network when the terminal is connected to a network which does not belong to the geographical entity of origin.

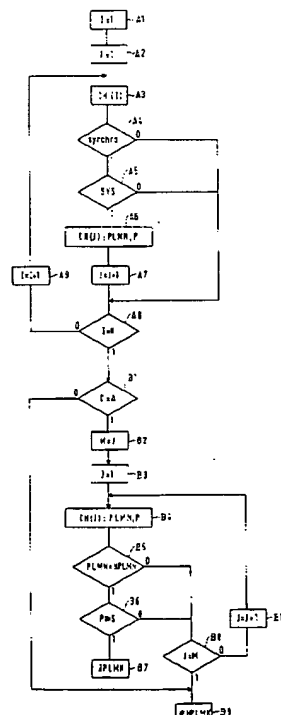
7 Claims, 3 Drawing Sheets

FIG. 1

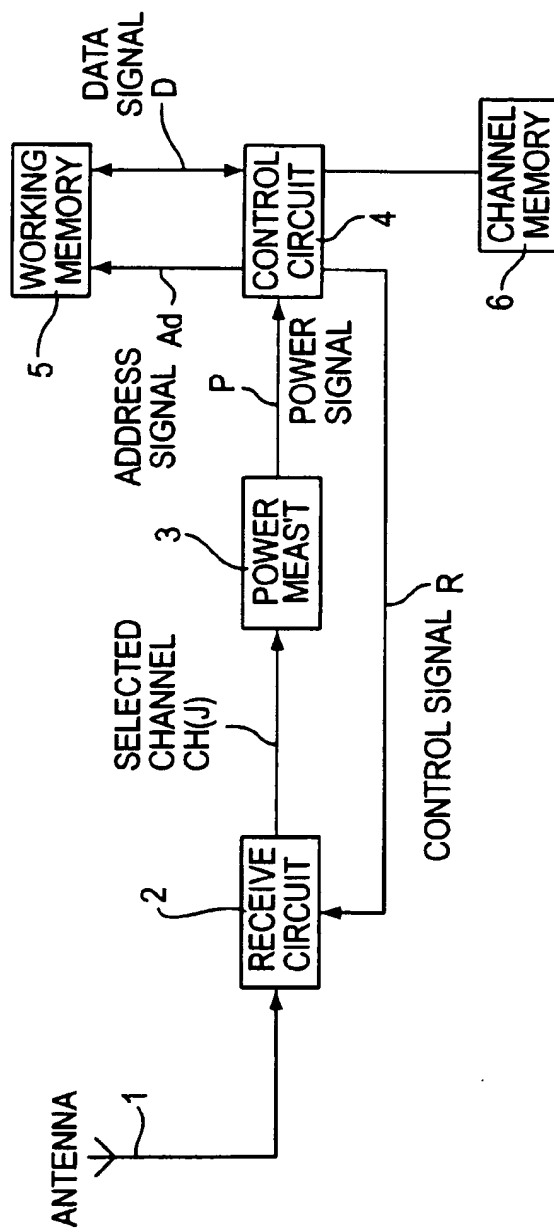
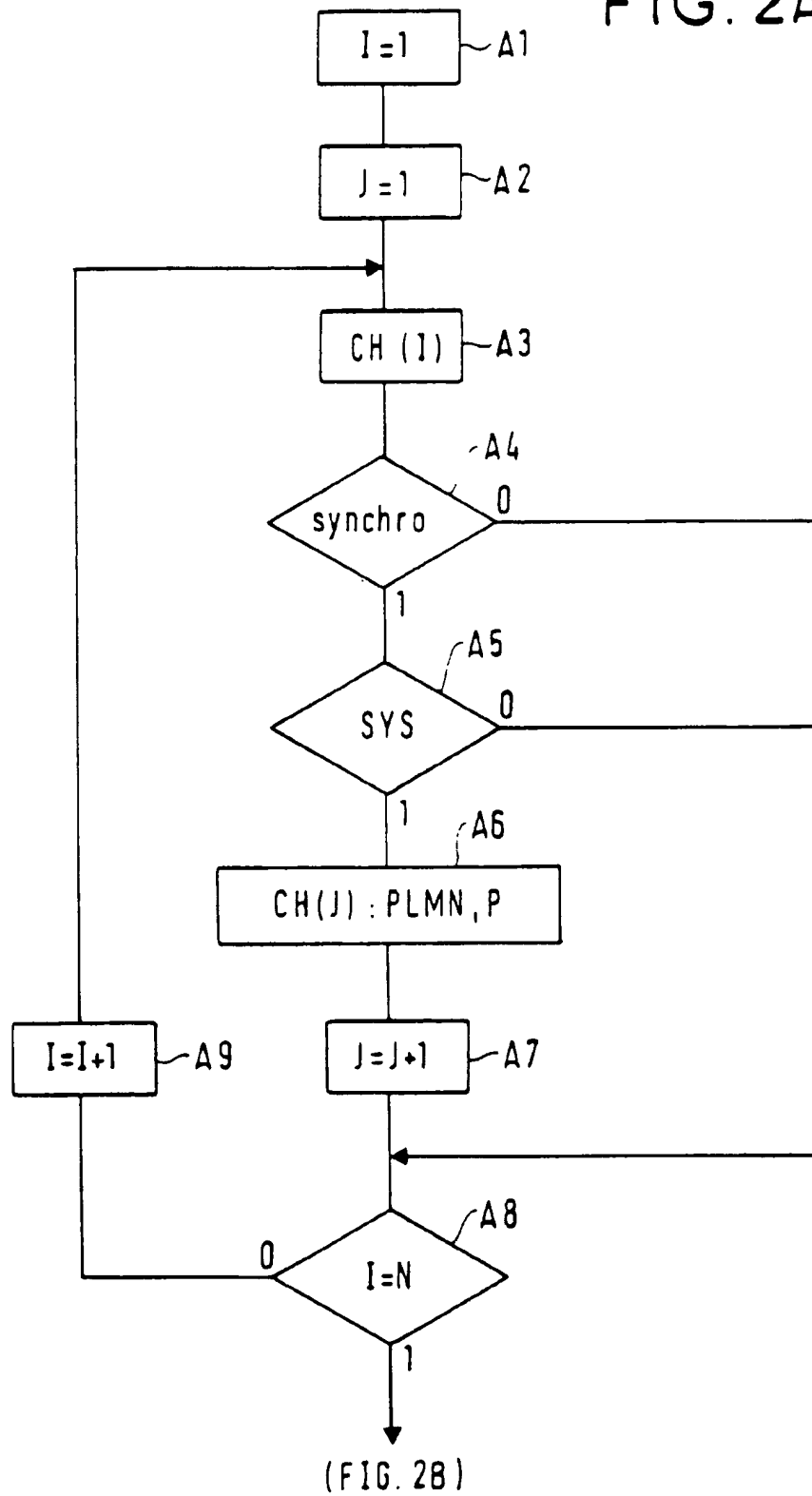
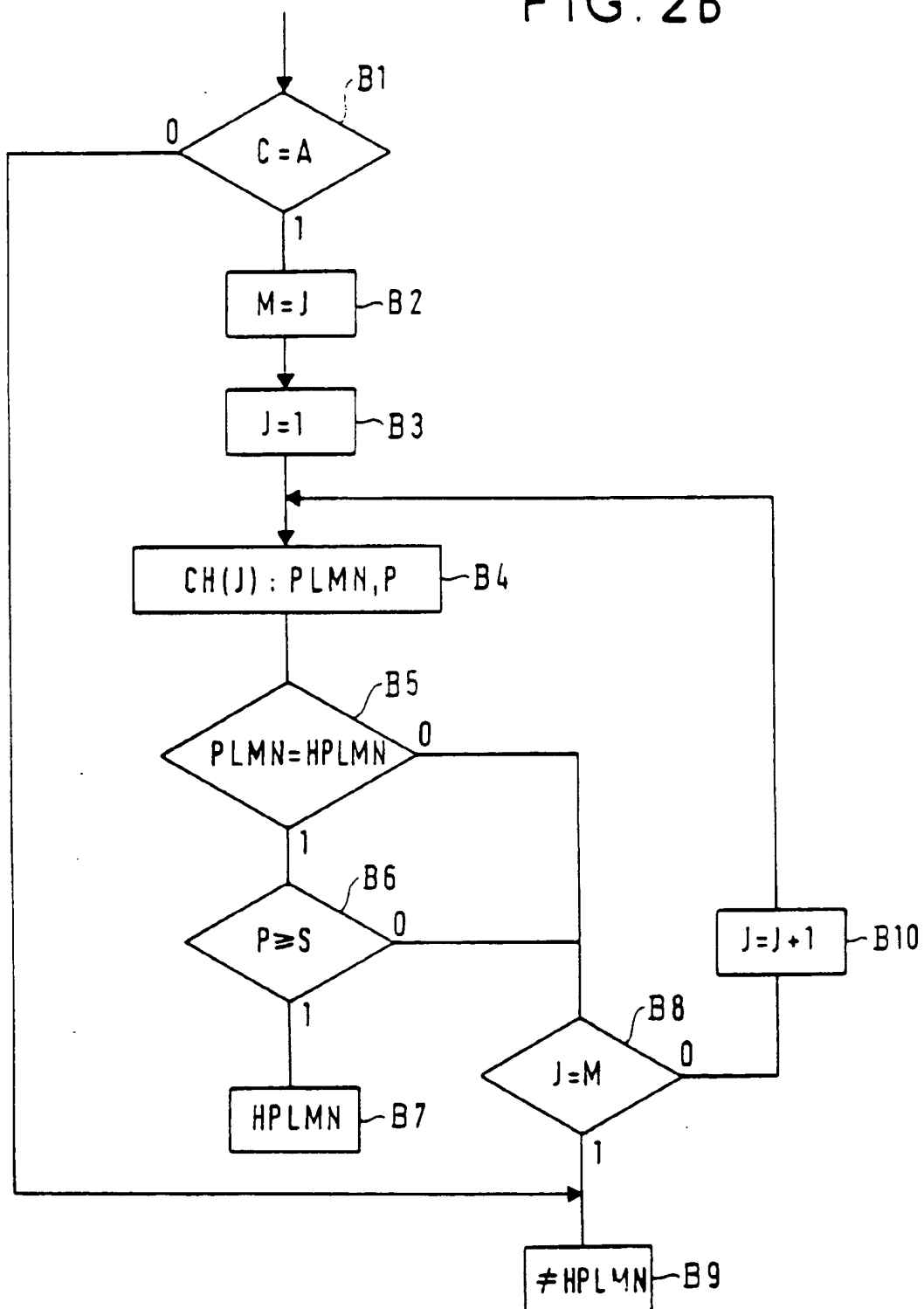


FIG. 2A



(FIG. 2A)

FIG. 2B



1

DEVICE FOR SEEKING CONNECTION OF A TERMINAL TO A NETWORK OF A MOBILE RADIO SYSTEM COMPRISING A PLURALITY OF NETWORKS

This is a Continuation of Application Ser. No. 08/166, 954 filed Dec. 15, 1993 abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention concerns a device for seeking connection of a terminal to a network of a mobile radio system comprising a plurality of networks.

2. Description of the Prior Art

Reference is made here to mobile radio systems covering a plurality of geographical entities (countries, for example) as is the case with the GSM paneuropean digital cellular mobile radio system. A system of this kind comprises a plurality of radio networks usually managed by different operators, each network covering a territory corresponding to all of a country or to one or more regions within a country. These radio networks are connected to the cable networks of the corresponding countries so that a mobile radio system terminal can communicate with a cable network terminal.

There may be several radio networks in the same country, their coverage areas overlapping partly or totally. Then, if a terminal wishes to access the mobile radio system, because there is a choice the question arises which radio network it will connect to. To this end the terminal includes a connection seeking device to establish a list of the radio networks to which it could connect.

A particular terminal which can operate throughout the mobile radio system is affiliated to a specific radio network, the home network, in just the same way as a telephone terminal is affiliated to a specific cable network. The reason for this is that the terminal is the means of obtaining services such as speech or data communication provided by the network operator who needs to know the identity of the terminal, in order to bill for the services provided if for no other reason.

It is desirable for priority to be given to connecting a terminal to its home network. The terminal user has an agreement with an operator who provides certain services that a different operator may not necessarily be able to supply; this applies to data communications, for example. Also, if a terminal connects to a radio network that it is convenient to refer to as a "visitor" network separate from its home network, this presupposes that the two operators concerned have an agreement authorizing such connection. This is not always the case, but assuming that it is, it is necessary for information to be exchanged between the two networks for the terminal's calls to be managed. The first item to come to mind is the cost of the service provided on the visitor network which must be passed on to the terminal's home network in order for the user to be billed accordingly.

It is therefore known for the connection seeking device of a terminal to be activated regularly either by manual action of the user or automatically when the terminal is connected to a visitor network of the same country as its home network, so that it breaks the connection with the visitor network to establish a new connection with the home network. This procedure is described in GSM recommendation 03.22 and is applied only if the visitor network is in the same country as the home network, the country of origin. It seems illogical

2

to apply it if the visitor network is in another country because the networks are designed to serve the terminals of a given country. For example, a terminal whose country of origin is France and which is located in Denmark must not attempt to connect to its home network as it would necessarily fail.

Over and above this, the procedure mentioned above naturally consumes power which reduces the operating time between battery recharging/replacement in the case of a terminal having a battery of limited capacity. This is further argument for not applying this procedure when the visitor network is not in the country of origin.

However, if the terminal is in a border area between two countries, it can have access to a network of each country because, given the type of transmission used, it is not possible to limit the coverage area of a network precisely to the border. It can even happen that the terminal, even though in its country of origin, can connect only to a network of another country because transmission conditions (radio propagation conditions) prevent it connecting to its home network or to a visitor network of its country of origin. This occurs if it is in a shadow area in the sense in which this term is used in the radio art, behind an obstacle such as a mountain which prevents this connection, for example. The terminal is thereby penalized and can no longer access its home network even if transmission conditions should become favorable again.

An object of the present invention is to enable a terminal to establish a new connection with its home network when it is connected to a visitor network which is not of its country of origin.

SUMMARY OF THE INVENTION

This object is achieved by providing in the terminal a device for seeking connection to a network of a mobile radio system comprising a plurality of networks, said system extending over a plurality of geographical entities each having at least one network, the terminal being affiliated to a home network belonging to a geographical entity of origin, the device comprising seek means for seeking the connection to the home network when it is connected to a network which does not belong to the geographical entity of origin.

As already mentioned, the above device consumes power even if it is activated at relatively widely spaced time intervals.

A further object of the present invention is to reduce the power consumption of the terminal.

This object is achieved by having the device hold a table listing the geographical entity of origin and the geographical entities adjacent thereto and comprise selector means for activating the seek means only if the network to which it is connected belongs to a geographical entity in said table.

An additional problem arises when the connection to the home network can be achieved but would be of mediocre quality with a high risk of being interrupted.

A further object of the invention is therefore preventing the achieving of a connection that is highly unsatisfactory from the terminal's point of view

This object is achieved by having the device hold a quality indicator in respect of the connection to said home network established during scanning of all the networks to which a connection can be achieved and comprise inhibitor means for preventing connection to said home network if said quality indicator is less than a predetermined quality threshold.

In one specific embodiment of the device the terminal is connected to a network by a connection whose quality constitutes a reference value and the quality threshold is the sum of a predetermined safety margin and said reference value.

Advantageously the connection between the terminal and any network of the mobile radio system uses at least one radio channel conveying a control signal and said quality indicator represents the power at which the terminal receives the respective control signal.

The invention is now described in more detail by way of purely illustrative example and with reference to the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the main components of a terminal needed to implement the invention.

FIGS. 2a and 2b constitutes showing the operation of the connection seeking device.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Before seeking a connection a terminal must carry out a synchronization procedure which will now be described in outline in order to clarify the explanation.

In mobile radio systems such as the GSM paneuropean digital mobile radio system, for example, a terminal communicates with a base station by way of communication channels conveying radio signals. These systems comprise a plurality of channels for transmissions from the terminals to the base stations or for transmissions from the base stations to the terminals.

These channels include a control channel which is transmitted continuously and which enables a terminal to access the system via the base station transmitting this channel in order to set up calls. The terminal must therefore identify this control channel in order to acquire the information enabling it to declare itself in the system. This information includes synchronization information and for this reason this procedure is usually called the synchronization procedure.

A two-stage method is usually adopted to achieve synchronization. In a first stage the terminal measures the power on all received channels. The terminal then attempts to synchronize with the channel received at the highest power. If it fails to do so it tries the other channels in decreasing received power order until it is able to synchronize. This method is that which is the subject of GSM Recommendations 4.08 version 3.11.0 and 5.08 version 3.7.0.

The synchronization procedure is carried out systematically whenever the terminal is switched on and also, and more generally, after any loss of synchronization, i.e. if the link between the base station and the terminal is interrupted. It is also undertaken in the instance of interest here, i.e. when the terminal is already connected to a network, for the purpose of identifying the various networks to which it could connect.

Referring to FIG. 1, in a known manner, the terminal essentially comprises an antenna 1 to receive the various channels, there being N channels, a receive circuit 2 such as a frequency synthesizer connected to the antenna 1 and which selects from these channels a tuning channel CH(I) in response to a control signal R, a power measuring circuit 3 which produces a power signal P representing the power on the tuning channel CH(I), and a control circuit 4 such as a microprocessor which produces the control signal R and

which receives the power signal P and stores it in a working memory 5 by means of a data signal D at an address assigned to the tuning channel CH(I) by means of an address signal Ad.

Also in a known manner the control circuit 4 has access to the identity of all the channels that the terminal can receive. For example, there may be a channel memory 6 associating for each channel a set point value of the control signal R with an address in the working memory 5. Thus during a first period the control circuit 4 produces the control signal R with one of the set point values and stores the value of the power signal P in the working memory 5 at the address associated with this set point value in the channel memory 6. The control circuit repeats this operation for all set point values with the result that the working memory 5 contains a power value for each channel.

It then classifies the channels in the working memory 5 in decreasing power order, retaining for each channel an indication of the respective set point value. The result of this operation is thus a first list of the set point values classified in decreasing power order of the respective channels.

The operation of the terminal is now explained with reference to the block diagram shown in FIG. 2 and with the convention that a positive response to a test is assigned the value 1 and a negative response is assigned the value 0.

Referring to FIG. 2A, the control circuit 4 carries out an initialization phase in which it sets the value of I to 1 in a block A1 and the value of J to 1 in a block A2.

In block A3 the control circuit selects as the tuning channel CH(I) the receive channel identified by the index I, that at the Ith location in the working memory 6, using the respective set point value.

In block A4 the control circuit 4 causes the terminal to attempt synchronization by seeking the synchronization information present on each control channel. If this attempt fails the control circuit executes block A8 described later.

If synchronization is achieved the control circuit 4 causes the terminal to seek the system information i.e. the network PLMN which is transmitting the respective control channel (block A5). If this information cannot be found the control circuit executes block A8 described later.

If the system information is found, the control circuit 4 writes into a second list in the working memory 5 at the Jth location the set point value respective to the selected channel CH(J), the network PLMN and the power P at which this channel is received (block A6).

The value of J is then incremented by one (block A7).

In block A8 the control circuit 4 tests the value I to determine if all the receive channels have been examined. If I is less than N it increments it by one in block A9 in order then to execute block A3. If I is equal to N, however, this phase of operation is terminated and the result is the second list in the working memory 5 giving the characteristics of the M channels by means of which it is possible to connect to the system.

The connection seeking device proper, which essentially comprises the control circuit 4 and the working memory 5, is now described with reference to FIG. 2B.

In block B1 the control circuit 4 checks if country C of the visitor network to which the terminal is currently connected is an adjacent country A of the country of origin (the country of the home network HPLMN of the terminal). It is not necessary to seek a connection to the home network if the terminal is very far away from the country of origin. For example, the terminal holds a table in a memory area which

could be part of the channel memory 6. This table lists the identification codes of the country of origin and the various countries A adjacent to it. Thus if the country of origin is France, this table lists France, Belgium, Luxembourg, Germany, Switzerland, Italy and Spain. The control circuit 4 has previously memorized the code of the country C of the network to which it is currently connected and checks if this code is in the table. If not, it executes block B9 described later. If yes, it executes an initialization phase beginning with block B2.

It is important to realize that execution of block B1, although having its own advantages, is not strictly necessary to implementation of the invention. If this option is not chosen, the control circuit 4 goes direct to executing block B2 after block A8.

In block B2 the control circuit 4 assigns the value of J previously calculated to the variable M which represents the number of items in the second list. Then, in block B3, it assigns the value 1 to the variable J again.

The control circuit 4 then reads in the working memory 5 the Jth item of the second list in order to obtain the network PLMN and the power P of the respective control channel (block B4).

In block B5 the control circuit 4 checks if the network PLMN is the home network HPLMN. If not, it goes directly to executing block B8 described later. If yes, it executes block B6.

In block B6 the control circuit 4 checks if the respective control channel is received with sufficient power P. The terminal must not connect to a network if the connection would have to be interrupted shortly afterwards because of insufficient quality. It is therefore prudent to ensure that the connection to the home network HPLMN is authorized only if the power P exceeds a predetermined threshold S. This threshold S may be set absolutely or defined relative to the reference power with which the control signal transmitted by the visitor network to which the terminal is currently connected is transmitted. In this latter case the threshold S is the sum of the reference power and a safety margin which can have a positive, null or even negative value. The control circuit 4 which has this previously stored predetermined safety margin and the reference power acquired during synchronization to the visitor network is therefore able to calculate the threshold S. The quality of connection has been assessed here by assessing its power. The invention is equally applicable if it is assessed by means of some other indicator, such as an error rate, for example.

It is important to realize that execution of block B6, although having its own advantages, is not strictly necessary to implementation of the invention. If this option is not chosen the control circuit B goes directly to executing block B7 after block B5 if in the latter it has been established that the network PLMN examined is the home network HPLMN. Note that in this case it is not necessary to memorize the power P of the channel being processed in block A6.

If this option is adopted, on the other hand, the control circuit 4 executes block B8 described later if the power P of the selected channel CH(J) is below the threshold S; if not, it executes block B7.

In block B7 the control circuit establishes if it is possible to connect to the home network HPLMN using the selected channel CH(J) and commands the terminal accordingly. The means for establishing the connection are not described in more detail here as they are part of the prior art and are not within the scope of the present invention.

In block B8 the control circuit checks if all the channels in the second list have been examined, i.e. if J is equal to M.

If not, it executes block B10 described later; if yes, it executes block B9.

In block B9 the control circuit 4 has already established that it is not possible to connect to the home network HPLMN. Subsequent actions are outside the scope of the present invention, but a simple solution is not to modify the connection already established.

In block B10 the control circuit 4 increments the value of J by one and executes block B4 again to examine the next channel in the second list.

The connection seeking device operates automatically, i.e. it repeats the series of operations described above with reference to blocks A1 through B10 in a regular manner. This repetition may be subject to a time-delay commanded by the control circuit 4, for example.

Also, the invention has been described in relation to networks belonging to countries. This is merely one example and the invention is equally applicable if these countries are replaced by geographical entities comprising more than one country or part only of a country. What is important is that a geographical entity of this kind comprise one or more networks and that these networks are limited to this entity: a network can cover all or part of the geographical entity but it cannot extend beyond its boundaries. The only exception to this is that explained in the preamble, and with which this invention is concerned, and is due to the mode of transmission: it is not possible to halt radio transmission on a predetermined boundary line.

There is claimed:

1. A device for seeking connection of a terminal to a network of a mobile radio system comprising a plurality of networks, each of said networks including a plurality of base stations, each of said base stations having a plurality of communication channels which are capable of providing network connections when synchronized with the terminal, said system extending over a plurality of countries each having at least one network and said terminal being affiliated with a home network belonging to a country of origin, the device comprising: seek means for seeking the connection of the terminal to said home network when the terminal is connected, using a communication channel with which the terminal is synchronized, to a network which does not belong to said country of origin; and means for establishing the connection of the terminal to said home network.

2. The device according to claim 1, further comprising means for holding a table listing only said country of origin and countries adjacent thereto, and selector means for activating said seek means only if the network to which the terminal is connected belongs to a country in said table.

3. The device according to claim 1, further comprising means for holding a quality indicator in respect to the connection to said home network established during scanning of all the networks to which a connection can be achieved, and inhibitor means for preventing connection to said home network if said quality indicator is below a predetermined quality threshold.

4. The device according to claim 3 wherein said terminal is connected to a network by a connection whose quality constitutes a reference value and said quality threshold is set relative to said reference value.

5. The device according to claim 3, wherein the connection between said terminal and any network of said mobile radio system uses at least one radio channel conveying a control signal, and said quality indicator represents a power at which said terminal receives the respective control signal.

6. In combination: a terminal; a mobile radio system comprising a plurality of networks, each of said networks

7

including a plurality of base stations, each of said base stations having a plurality of communication channels which are capable of providing network connections when synchronized with the terminal, said system extending over a plurality of countries each having at least one network, said terminal being affiliated with a home network belonging to a country of origin; and seek means for seeking a connection of the terminal to said home network when the terminal is connected, using a communication channel with which the

8

terminal is synchronized, to a network which does not belong to said country of origin.

7. The combination according to claim 6, further comprising means for holding a table listing only said country of origin and countries adjacent thereto, and selector means for activating said seek means only if the network to which the terminal is connected belongs to a country in said table.

* * * * *